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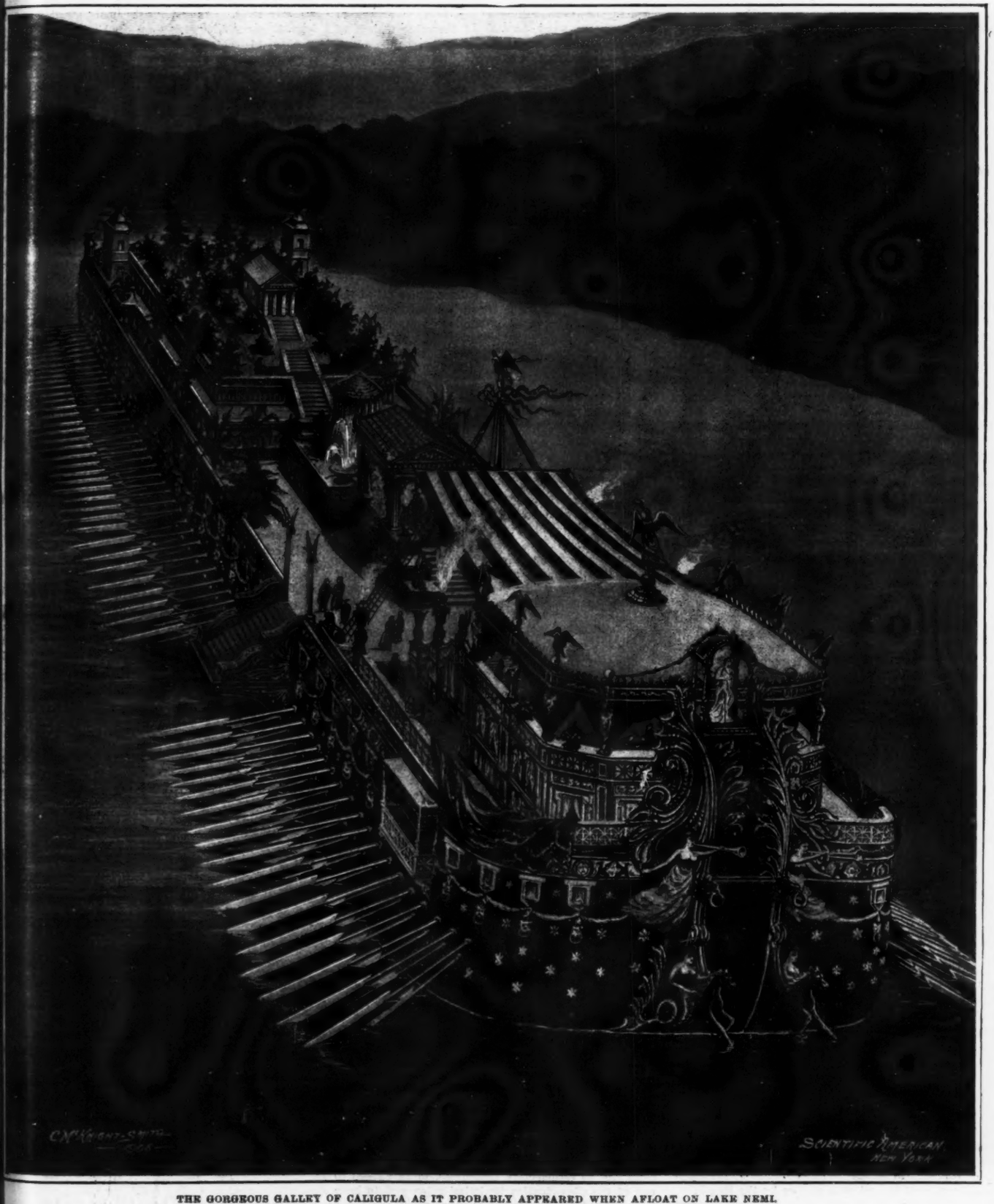

THE GORGEOUS GALLEY OF CALIGULA AS IT PROBABLY APPEARED WHEN AFLOAT ON LAKE NEMI.

CALIGULA'S GALLEYS IN THE LAKE OF NEMI.—[SEE PAGE 249.]

MODERN SHIP DESIGN.*

FROM DRAFTING BOARD TO TRIAL TRIP.

BY LESLIE DENNY.

The general principles involved in the design of a vessel are the same whatever type is required, and it must be assumed that a large amount of data derived from vessels previously built are available for preliminary estimates. So full are these data possessed that it is possible to scheme out a vessel in the course of an hour, which is so nearly correct that when passed to the drawing office for more careful analysis only minor alterations have to be made. The principal items tabulated are the dimensions of the vessel, of her machinery, her tonnage, and its distribution in detail, her displacement and weights in detail, particulars as to her stability, capacity, rig, class, details as to passengers, number of staterooms, water ballast capacity, fresh water capacity, the length of engine room and boiler room, dimensions of cylinders, stroke, kind of engine, number of boilers, their length, diameter, description, and working pressure, number of furnaces, diameter of same, heating surface, grate surface, diameter and pitch of propellers, or paddle wheels, then follow particulars of the trial trip, giving draft, displacement, power, speed, revolutions, slip, ratio of heating surface to grate surface. Then follow details as to form, then coefficients worked out from these, which are used in estimating.

The following are a few of the terms used:

The dimensions usually taken are molded dimensions. The length is the length on the water line between the front of the stem and the back of the sternpost.

The molded breadth is the greatest breadth amidships over the frame and inside the skin plating.

The molded depth is the depth from the top of the keel to the top of midship frame at side.

Tonnage is somewhat of a mystery to those unconnected with shipbuilding and shipowning, but broadly the gross tonnage is the entire internal capacity of the vessel, taken in cubic feet divided by 100, while the net tonnage is this figure less deductions for machinery space, crew space, also light and air for machinery, etc. In a typical cargo boat whose dimensions were 410 feet by 50 feet 6 inches by 32 feet the gross tonnage was 5,149, while the net tonnage was 3,323 tons, the difference of 1,826 was made up by allowance for space occupied by propelling power 1,673, for crew space 153.

In our calculations for displacement, etc., we use the molded draft, which is the draft as shown on the draft marks forward and aft minus the thickness or depth of the keel. We do this because vessels are fitted with different kinds of keels, some as much as 12 inches deep, whereas other owners prefer to turn the keel on its flat, and while it may be 12 inches broad it will only be 2½ inches to 3 inches deep. Now the displacement of a vessel can best be described as follows: Suppose a vessel floating freely in salt water and that suddenly by some means she was frozen solidly in, and that then she was lifted out of the ice; there would remain in the ice an exact mold of her shape. If, then, this mold was filled with salt water through a meter, the number of cubic feet of water divided by 35 would give the tons displacement of the vessel, which is the weight of the vessel, and any cargo, etc., she may have on board at that time. Shipbuilders now use the Amsler planimeter for ascertaining this displacement from the drawings. Now the data previously mentioned are analyzed and tabulated not only directly, but also in the form of coefficients; thus the cubic feet of displacement is compared with that of a block, or parallelopipedon, having for dimensions the length, breadth, and draft molded, and a coefficient which is commonly called the block coefficient is obtained. For example, to take the vessel just referred to, her dimensions were 410 feet by 50.5 feet, and on trial her molded draft was 24.62 feet, and her displacement 11,870 tons. If this be multiplied by 35 the cubic feet displaced comes to 415,000. Now multiply the length by the breadth by the draft—that is, 410 feet by 50.5 feet by 24.62 feet, and we get the figure 510,000. If 415,000 be divided by 510,000, we get the figure 0.815, which is called the block coefficient.

Other coefficients are used, such as midship area coefficient, which is the area of the midship section divided by the area obtained by multiplying the breadth by the draft. There is also the prismatic coefficient, which is the volume of the displacement in cubic feet divided by the volume obtained by multiplying the area of the midship section by the length.

* Abstract of a paper delivered before the Manchester Association of Engineers.

Now in regard to weights. For the purpose of estimating, the weights are divided into three rough items, namely:

First, net steel, which is the net weight of the steel hull structure of the vessel, namely, all the frames, reverse frames, floors, beams, shell plating, deck plating, casings, and the rivets to attach them.

Second, wood and outfit, which comprises the wood used in the decks, ceiling of the hold, woodwork in cabins, masts, spars, as also all the other fittings of the deck, such as windlasses, winches, hawse pipes, boats, davits, rigging, awnings, sails, etc., indeed everything except the net steel weight and the machinery.

Third, the machinery weight, comprising the engines, boilers, tunnel shafting, propellers, condensers, and the water in the boilers and condensers.

These three items make up what is called the net weight of the vessel, and then a fourth item is the dead weight, which covers coal, fresh water, and provisions for the passengers and crew, the weight of the crew and passengers, and in addition any paying dead weight which the owner may desire to carry. The latter in the case of cargo vessels is the largest item, while in the case of passenger vessels the paying dead weight is naturally very small. The handiest method for the steel and wood weight in similar ships is to take as a basis a figure called the "cubic number," which is simply the length, breadth, and depth of the vessel multiplied together and divided by 100. If the net steel weight and the wood weight be divided by this figure a fraction coefficient is obtained. This varies with different types of boats, but quite a common value for an ordinary boat is 0.38 for the steel and 0.14 for the wood. For the machinery the common method is to have tabulated the number of indicated horse-power produced per ton of total machinery weight. This again varies, being high in the case of fast passenger steamers and low in slow cargo steamers. Five is not an uncommon figure for a cargo vessel, about ten for cross-Channel steamers, and a much higher figure still for such vessels as torpedo boats.

For practically all the vessels finished complete in this country we have carried out what is called a measured mile trial. By taking the mean of the speeds (not the mean of the times) and the mean of the powers, the power required to drive the vessel at any particular speed on the measured mile is obtained.

By means of these trials a curve of speed and power was constructed, which could be produced at each end for a reasonable distance. At the same time the revolutions were observed, and they were found to be at 9.1 knots 47 revolutions, at 10.8 knots 58 revolutions, 12 knots 64 revolutions. The reason for the progressive trial is that while the speed for this vessel was specified to be from 11½ to 12 knots, other owners might ask for a similar vessel to steam only 10½ on similar dimensions, the engine and boilers could then be reduced, because the power at 10½ would be only 1,440, as ascertained from the curve. One would thus be in a position to say at once what the power was, and could design the engines and boilers so as to produce the most economical result. But one might be asked for a vessel which was not of identical dimensions, and then modifications would be necessary to ascertain the power for this purpose. A very convenient way is to use what is called the "Admiralty Constant," obtained as follows: The displacement is taken and the two-thirds power ascertained, this is then multiplied by the speed in knots cubed, and the whole is divided by the indicated horse-power. This coefficient is called the "Admiralty Constant," which, though far from constant, is exceedingly useful in ascertaining the power when used with discretion.

Other useful tabulated figures are the power obtained per square foot of grate and per square foot of heating surface, as by this means it is easy to see at a glance what any particular type of boiler can be expected to produce in the way of power.

Take now a concrete example to illustrate the procedure in designing a vessel. Sometimes all the particulars received from the ship owner are that he wants a vessel to steam, say, 12 knots, to carry 5,000 tons of dead weight on 24 feet, to have, say, 50 first-class and 50 second-class passengers, to be classed to one of the Classification Societies' rules, and to have a Board of Trade certificate. In other cases the owner, having had previous experience, specifies general dimensions, the speed, the number of passengers, and dead weight. It may be of interest to state that I have known cases in which we have been asked to carry a certain amount of dead weight in a vessel of a special type, where even if the block coefficient had been unity she could not possibly have done it.

The following example shows details of calculations for a cargo and passenger vessel which was actually built. Owners' requirements about 360 feet long, to carry 6,000 tons total dead weight at a draft of about 24 feet, and to steam 10½ to 11 knots at sea.

From previous experience ratio of beam to length should be about 1 to 8, and depth about 0.65 of beam. Then try dimensions—

$$360 \times 45 \times 29, \text{ cub. number} = \frac{360 \text{ ft.} \times 45 \text{ ft.} \times 29 \text{ ft.}}{100} = 4{,}698.$$

A somewhat similar ship already built, but about 20 feet shorter, had net steel coefficient = 0.35, and wood weight coefficient = 0.11, here due to slightly more erections, etc., required, say, net steel, $0.36 \times 4{,}698 = 1{,}690$. For wood, more accommodation and decks required, say, 13, then wood $= 0.13 \times 4{,}698 = 610$. Machinery weight for type-ship, whose speed at sea had been 10½, was 338; here larger ship and rather better speed required, say, 375 for first approximation. Then weights—

Net steel	1,690
Wood and outfit	610
Machinery	375
Dead weight	6,000
	8,675

Say, 8,700 tons, with a margin of 25 tons.

8,700 tons at 24 feet gives a block coefficient as follows:

$$\frac{8{,}700 \times 35}{360 \times 45 \times 24} = 0.784.$$

Type-ship had dimensions 345 × 44 feet 6 inches × 22 feet draft on trial displacement = 7,490, block coefficient, 0.783, so that she was not very far different; her power at 10¾ knots was 1,500, therefore Admiralty constant

$$= \frac{\Delta^{\frac{2}{3}} \times V^3}{\text{I. H. P.}} = \frac{385 \times 1{,}242}{1{,}500} = 317.$$

Dealing with other typical ships in the same way, it was found that none of the others gave such a high constant, showing that the above vessel was abnormally efficient, which indeed was the case, and it was therefore decided not to exceed 300 as the constant for the new ship.

Then

$$\text{I. H. P.} = \frac{\Delta^{\frac{2}{3}} \times V^3}{C} = \frac{423 \times 1{,}242}{300} = 1{,}750 \text{ I. H. P.}$$

This gives power required on trial for the ship, but owners wished speed at sea, and hence, say, 20 per cent must be added to this.

$$\frac{1{,}750 \times 120}{100} = 2{,}100 \text{ I. H. P. at sea.}$$

Now type-ship was capable of doing 1,800 at sea, and her weight of machinery was 338.

$$\text{I. H. P. per ton of machinery was } \frac{1{,}800}{338} = 5.3.$$

$$\text{Hence weight} = \frac{2{,}100}{5.3} = 395.$$

Therefore apparently the first estimate for machinery weight was too small. The final figures were as follows:

	Ship estimate.	As built.
Dimensions,	360 ft. × 45 ft. × 29 ft.	360 ft. × 45 ft. × 29 ft.
Draft	24 ft.	23.78
Displacement	8,700	8,615
Net steel	1,690	1,662
Wood and outfit	610	549
Machinery	375	284
Dead weight	6,000	6,000
Margin	25	....
	8,700	8,615

Showing the estimate to have been on the safe side.

This shows how the first rough estimate for a ship

is got out, and afterward, of course, the design is fully worked out in the drawing office. This procedure is practically the same for all ordinary vessels, but for special vessels, such as those your president is more immediately interested in, while the first rough calculation, so far as weights are concerned, is made in a similar fashion, when dealing with speed and power, especially where a departure has occurred from anything previously done, another factor is introduced and that is the data got from an experimental tank, where such is available. While you may not be familiar with the details of such a tank, you know generally it is a long canal, in my firm's case, 300 feet long by 22 feet broad by 10 feet deep, over which there is a pair of rails on which runs a carriage and attached to this carriage is an accurate model of the ship immersed in the water to her correct designed draft. The truck is driven along by means of electric power at suitable speeds, and by somewhat elaborate calculations the resistance of the model is obtained. This resistance is then translated into resistance for the full-sized ship, and by this means a curve is obtained of what is called the effective horse-power, or the horse-power which would be necessary to tow the ship. But the difficulty of deciding the power which must be placed in the ship to drive herself at this speed only begins at this point, because it is found that this power is very considerably greater than the effective horse-power, indeed sometimes as much as double, or even more—that is to say, the efficiency of the propulsive apparatus is, say, 50 per cent. In other words, suppose the effective horse-power of such a ship for 20 knots to be 4,000, then the indicated horse-power which would require to be placed on board, if the efficiency were 50 per cent, would be 8,000. The skill of the builder is shown in fixing this percentage and designing propellers or paddle wheels to produce it. Theory alone, unless backed up by ample practical experience, is of very little value in fixing the efficiency.

You will thus see that the procedure for an exceptionally fast vessel is somewhat different, and that the tank is the final court of appeal in such cases. After we have decided upon the power thought necessary, we, as a rule, make careful experiments with propellers, because quite small differences in propellers often make large differences in the results, and even after we have done all we can, we are only perfectly happy in the case of exceptionally fast vessels when the first double run on the measured mile confirms our calculations.

FLIGHT OF THE "ZEPPELIN I."

RECENT PERFORMANCES OF THE FAMOUS GERMAN AIRSHIP.

As MAY be known to our readers, the German government has put its new airship in the hands of the aeronautic battalion for further tests. Unfavorable weather delayed the filling of the balloon until March 6th. The first ascension was to take place on March 8th, but the motors were not in order, and could not be made to operate satisfactorily until the evening of that day.

Consequently, the first ascension of the airship took place on the morning of March 9th, lasting from 9:15 A.M. till 10 A.M., and serving as a drill for the members of the staff. The second ascension took place at 11 A.M., lasting until 12:30 P.M.

At the third ascension, the airship rose from the ground without assistance, and covered a distance of 150 to 200 kilowatts (93 to 124 miles), the voyage lasting for about 2½ hours, the estimated speed being about 1.3 meters per second (28½ miles an hour) even with a contrary wind.

By a fortunate coincidence, a meteorological station is situated on Lake Constance. Thus atmospheric conditions are tested by means of kites before each ascension, and unpleasant surprises are obviated.

Accordingly, on March 10th, an ascension was undertaken at 11:15 A.M., after the determination of the conditions of the atmosphere. The younger Count Zeppelin was in the car, but the elder Count Zeppelin did not ascend, though he had consented to accompany Major Sperling, Capt. Jena, and the younger count the previous day on the first military ascension. The descent was made very smoothly about 1 P.M.

In the afternoon, when the brisk wind which rose about noon had died down, the balloon was drawn out of the shed about 4:30 P.M., and remained out about three-quarters of an hour.

As the fine weather continued, another ascent was undertaken at 9:30 A.M. on March 11th.

On this trip special observations were made from above of the land in the neighborhood of the new balloon shed of the Zeppelin Airship Construction Company, with the object in view of attempting within a few days a descent upon *terra firma*. At 3 o'clock in the afternoon the airship again rose, coming down about 5:20 P.M. upon the surface of the water.

The flight on the 12th of March was the highest thus far attained with any airship of rigid construction, the balloon rising very rapidly to a height of some 900 meters, and afterward ascending still higher.

The greatest height reached was estimated from 1,500 to 1,800 meters (4,921 to 5,905 feet).

This flight had for its special object the testing of the horizontal rudders. Count Zeppelin himself took part in this test, the other participants being all military—the four officers and the mechanics of the Berlin Aeronautic Battalion.

On the 15th of March an event occurred which may prove to be of much significance in the further development of airships of rigid construction. The "Zeppelin I." rose shortly after 8 A.M., crossed over the city, and then descended on the place previously determined by the Airship Construction Company.

The descent was accomplished by making use of the horizontal rudders till the balloon was 25 to 30 meters (82 to 98 feet) above ground, when it was drawn down to earth by ropes in the hands of the men of the Aeronautic Division.

The photographs show these maneuvers very clearly, and also display the extreme ease and comfort with which communication is established between the car and the ground.

Part of the steering gear sustained a trifling injury by being dragged past a tree.

This first successfully planned and accomplished landing of an airship of the rigid type on *terra firma* took place in the presence of the Inspector of Troops, Lieutenant-General von Lyncker, and Major Gross, Commander of Aeronautic Battalions.

Encouraged by this success, a similar landing was undertaken on March 18th, and likewise accomplished smoothly and successfully.

In both cases the airship returned to the shed.

As soon as the "Zeppelin I." demonstrated that a descent upon solid earth could be made without difficulty, an extended voyage was planned, and on April 1st a journey to Munich was attempted.

The airship started from Friedrichshafen at 4:05 A.M., while it was still dark and cloudy. The start was made against a strong northeast wind. The huge air craft rose to a height of about 1,000 feet and was headed for Munich, 111 miles away. The principal intervening cities were brilliantly lighted, so as to show aerial navigators the course to be followed. Munich was reached shortly before 9 o'clock, and the airship's approach was signaled by the ringing of church bells and the firing of cannon. After reaching the exposition grounds the airship descended to within about 300 feet of the earth. A great crowd assembled, and the Prince Regent saluted Count Zeppelin as he stood in the car of his airship. The wind had increased in intensity, and the Count was afraid to attempt a landing. The airship again soared aloft, and soon it was being driven before the wind. It was impossible to hold the huge air vessel against the gale, which soon attained a velocity of nearly 40 miles an hour. Consequently, since it had a speed of but 26 miles an hour, it drifted at the rate of 14 miles an hour, and in five hours' time reached Dingolfing, 70 miles from Munich. Here the Count attempted to land, and he was successful in accomplishing this dangerous maneuver. The airship was moored over night without damage, and at 11:15 the next morning it reascended in a moderate wind, and returned to Munich in 2¼ hours. Another successful landing was made on the parade grounds on the outskirts of the city, and Count Zeppelin was decorated with a gold medal by the Prince Regent of Bavaria. At 3:30 P.M. the airship again reascended and started for Friedrichshafen, which place was reached at 8 P.M. at a speed of about 24.6 miles an hour.

On April 5th the airship started at 9:18 A.M. on a 24-hour endurance trip; but owing to unfavorable weather conditions, this was abandoned, and the airship returned to its shed at 7:25 P.M. During the nine hours that it had been in the air, it descended twice to the surface of Lake Constance to take in water ballast. The airship traveled to Biverach, and then returned to the lake, where it spent most of the time in executing various maneuvers. A strong easterly wind rose early in the evening, and as it was impossible to make much headway against this wind, the airship was returned to its floating shed. The following day a short flight was made across the lake to Constance, and the airship landed successfully on the parade ground near the city. On April 7th the airship made a 12-hour flight, going first to Wanger in Wurtemburg, and then returning to Friedrichshafen by another route. The trip was entirely successful.

These flights are the first that have been made by the officers of the German army. In some of them as many as twenty-six men were carried upon the airship. This vessel is the remodeled "Zeppelin III." which has been renamed "Zeppelin I.," since it is the first Zeppelin airship to be taken over by the German government. Another new airship—the "Zeppelin II."—is almost completed. It is the purpose of the German government to have one such airship at each important fort on the outskirts of Germany. The management of the Frankfort Aeronautical Exposition, which is to be held from June to October, have also contracted for one of these airships for exhibition purposes.

The demonstration which was given during the trip to Munich on April 1st shows that the rigid type of airship is entirely practical, even under the most severe weather conditions. The fact that it was able to land on the ground without sustaining any serious damage shows that such a vessel can be used for transporting people, and landing them safely in case of accident. We look for the building of large numbers of these vessels for passenger transportation in the near future.

PASSENGER CAR WINDOW GLASS. A SUGGESTION FOR INVENTORS.

ONE feature of a railway car upon which all passengers are qualified to pass judgment is the window design. This part of a car structure is worth a careful study when new equipments are being planned. The shape of the windows has a great deal to do with the impression a car creates upon those who see only the exterior, as well as those who ride within the car. Next in importance to the proper contour for a car window and the choosing of the sash fixtures so that accidents may be minimized, is the choice of the glass. The cost of window glass is made up not only of the installation cost, but of the charges for maintenance occasioned by breakage. On the score of appearance, also, glass should present a smooth, flat surface, devoid of bubbles and irregularity. In general, the window sash of high-class cars are glazed with coach glass, polished plate, or so-called "cylinder" glass. The experience of the Kansas City Railway and Light Company has tended greatly to favor the latter named grade of glass, and is mentioned as illustrating the good results to be derived from careful observation of replacement materials and their costs. The records of this company for one year show that there were in operation cars with 10,000 sash containing cylinder glass 5/32 inch and 3/16 inch thick, and 9,000 sash with AA coach glass. All these cars were in city service. During the year the cost of replacements of the 10,000 cylinder glass windows was only about 55 per cent of the cost of replacing the AA glass. It is stated that the original cost of the cylinder glass is about three times that of the coach glass, but that a considerable economy is shown when the cost of glass and labor for renewals is considered. It is the careful observation of such maintenance details as these that serves to place a repair shop on a basis for maintaining equipments in the best condition at a low expenditure.—Electric Railway Journal.

In the eighteenth century the patient direct observations of William Herschel were crowned with the discovery of Uranus, and in the nineteenth century the solar system was extended by the calculations of Le Verrier to include Neptune. According to the American astronomer, W. H. Pickering, it is not impossible that in the twentieth century photography, by means of which the existence of the tenth satellite of Saturn, which cannot be seen with the most powerful telescope, has been demonstrated, may extend the frontier of the solar system still farther by revealing the existence of a planet more distant than Neptune. The most probable position of this planet at the commencement of the year 1909 has been calculated by Pickering, who has announced the following approximate co-ordinates: Right ascension, 7 hours 47 minutes; declination 21 degrees north. At the observatory of Arequipa, in Peru, photographs of this region of the sky have already been made, with the Bruce telescope of 24 inches aperture. Pickering expresses the wish that all astronomers possessing suitable instruments will join in the search and proposes a systematic exploration of this part of the zodiac.

PRONY BRAKES FOR PRACTICAL TESTING.

THE PROPER METHOD OF EMPLOYING A NOW ABUSED DEVICE.

BY G. EVERETT QUICK.

SOME form of apparatus for imposing an artificial load on engines, motors, etc., is well-nigh indispensable to builders of such machinery and will be found of great advantage to users also. In order to be of the greatest value, the apparatus must be such that the load which it imposes on the engine or motor can be accurately measured and completely controlled. Such apparatus is the absorption dynamometer, the simplest form of which is the friction brake.

For example, it is generally considered advisable to make the efficiency test of a water wheel after it has been installed, even though originally tested by the manufacturers. There are numerous details in the setting of the wheels which may alter the efficiency, and by using an inexpensive friction brake and a current meter, a test can be readily made by means of which the trouble may be located and corrected. A satisfactory brake can be built by the engineer in charge without difficulty if the instructions herein given are followed.

Except with very small powers, radiation and convection due to stray air currents will not be sufficient to dissipate the heat as rapidly as it is generated, and special provision for doing this must be made. This is most satisfactorily accomplished by a stream of cooling water circulating through an inclosed or partly inclosed jacket; by carefully regulating the supply the brake can be kept near the temperature at which it gives its best results. It is even best to cool the brakes used on small units in order to insure a reasonable degree of constancy in the load. In the common form of friction brake, where the brake arm is adjustably clamped to the brake wheel, a temperature change results in a contraction or expansion of the metal wheel and the adjusting screws must therefore be continually changed to keep the pressure between the friction members, and consequently the brake load approximately constant.

The best known type of friction brake is the widely used and much abused Prony brake, and in spite of its inherently bad features for certain work, its simplicity, cheapness, and applicability to nearly all kinds of motor of small and medium capacity enable it to maintain a place for itself in industrial testing. This brake is built in many different forms. More uniformity is noticed in the design of the brake wheel than in any other part. It is usually of cast iron, practically free from sand holes and with deep internal flanges at the rim to retain the cooling water. In the small sizes one side of the wheel is often completely inclosed, as shown in Fig. 1, while those of greater capacity have spokes so designed as to allow the water to circulate over the entire inner face of the rim between the flanges, as in Fig. 2. Frequently shallow external flanges are cast on the sides of the rim to act as guides for the brake arm, but usually these guides are fastened to the brake arm itself. The outer surface should have an unusually smooth finish and must be perfectly balanced and concentric with the axis of the shaft on which the wheel is to be mounted, in order to reduce to a minimum objectionable vibrations due to the rotation of an unbalanced mass. Where possible, the final cut ought to be made with the wheel mounted on its own shaft, the latter revolving in its bearings in the same relative position in which it is to be used. Usually in experimental work, and often in commercial testing, this wheel is securely keyed to a separate jack shaft made as short as possible and supported at both ends on rigid pedestals, with substantial bearings, preferably of the annular ball type and allowing only about 1/32 inch end play of the shaft. In fact, as all who have used the Prony brake are well aware, one of the chief disadvantages in its use is the uncertainty of the scale readings due to the tendency of the brake arm to vibrate excessively. These vibrations come from two sources, namely, failure of the wheel to run perfectly true under load (which may be due to springing of the shaft, unbalancing of the wheel, or a lack of rigidity of the bearing supports), and a chattering produced by the lack of a smooth engagement of the friction members. The dynamometer shaft is driven by the motor shaft through a universal joint which will not be a source of error if the two shafts are properly alined.

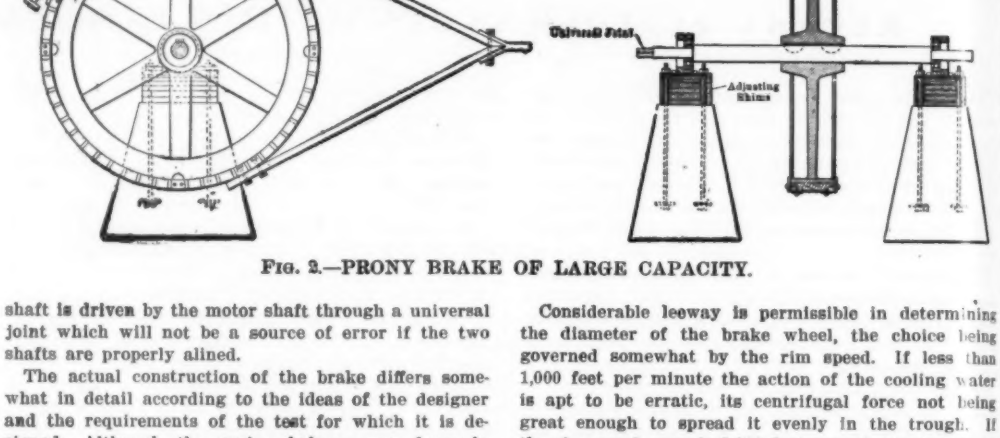

FIG. 2.—PRONY BRAKE OF LARGE CAPACITY.

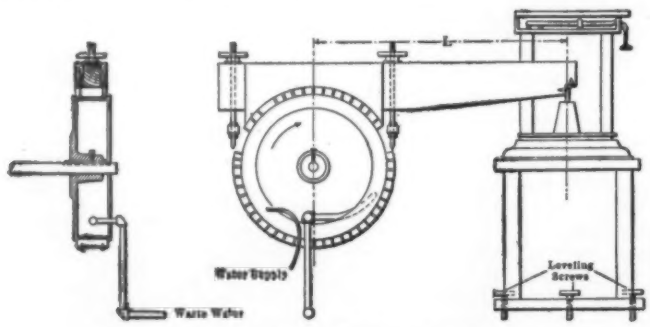

FIG. 1.—ONE FORM OF PRONY BRAKE.

The actual construction of the brake differs somewhat in detail according to the ideas of the designer and the requirements of the test for which it is designed. Although the spring balance was formerly used to some extent to indicate the pull at the end of the brake arm, its unreliability has caused it to be displaced by the beam balance and the suspension of a known weight. The latter is the most convenient means in commercial use. The smoothness of operation and accuracy obtained with such a brake depend somewhat on the material and condition of the frictional contact. Babbitt metal, bronze, soft and hard wood, leather, and cork have been used, but in commercial practice soft-wood blocks, with their grain at right angles to the motion of the wheel, are almost universally preferred. As indicated in the sketches, the blocks cover about 75 to 80 per cent of the rim surface, being spaced so as to leave an opening next to each block for the retention of the grease which should be freely used for lubricating the friction surfaces. These can be quickly worn to a good bearing surface by working with a heavy load for a short time without a supply of cooling water. The excessive heat will slightly char the surface of the wood and wear it to a true face very rapidly. Dry strips of leather which have no indication of being sticky or gummy, and for small powers flat pieces of cork with hardwood or metal retainers have been successfully used in reducing the vibrations.

Although oil or grease is ordinarily used for lubrication, some engineers use a jet of water or strong soap suds directed on the external surface of the wheel in place of the internal cooling water. Unless the brake is at least partially inclosed the liquid thrown from the revolving wheel makes surrounding objects look like a "kitchen floor on scrub day." Cooling in this way is not as uniform and with pure water the lubrication is so poor that the vibrations at the brake arm are excessive. With interial water cooling, the best results are obtained when the stream of water is regulated to keep the temperature a little below boiling. At the temperatures which are likely to prevail, a circulation of one pound of water per minute will dissipate heat equivalent to about two to three horse-power. Although not confined within definite limits, the depth of water in the annular trough is generally about 5/16 inch for every 25 horse-power absorbed, this value being slightly high for low speeds and a little low for high speeds. The scoop and outlet pipe should be of ample size and the former shaped to cut the water with a sharp edge nearly parallel to the direction of motion.

Considerable leeway is permissible in determining the diameter of the brake wheel, the choice being governed somewhat by the rim speed. If less than 1,000 feet per minute the action of the cooling water is apt to be erratic, its centrifugal force not being great enough to spread it evenly in the trough. If the rim speed exceeds 5,000 feet per minute, trouble is experienced with excessive vibrations. Average practice ranges between 1,500 and 4,000 feet per minute, the lower value for low-speed motors and the higher for high-speed motors.

Of the many different forms of brake arm, Figs. 1 and 2 show those in most common use. The former has a straight lever adjusted to a horizontal position by a level or otherwise, and is commonly used where a fairly low horse-power is combined with a high speed, requiring a brake wheel of small diameter, such as automobile engines, etc. As the effective length of this lever as used in the calculation for horse-power is the horizontal distance from the center of the brake wheel to the point of contact on the platform scales, it will be readily seen that the greater the diameter of the brake wheel or the shorter the brake arm, the greater will be any inaccuracy due to a variation from its true horizontal position. This error, however, is negligible if care is taken in leveling the arm. Both forms have a friction surface of soft pine blocks fastened in position by flexible steel strips, except the upper row of blocks in Fig. 2, which are fastened to the side pieces of the arm. With very small brakes, blocks may be omitted altogether and the arm and strap cut out of solid wood to fit the wheel.

When the vibrations are unusually severe an oil or water dashpot near the end of the lever arm, as *P*, in Fig. 3, is often used.

Another important detail in design that must be considered is the proper contact surface area. If the surface in contact with the pulley is too large, the load on the brake is not sufficiently sensitive to a variation in the adjusting screw and regulation is unsatisfactory. With too small a contact area, the regulation is over-sensitive and sudden shocks and vibrations are transmitted to the scale beam. Prof. Carpenter, in "Experimental Engineering," states that the value of

$$K = \frac{W \times V}{H.P.}$$

must not exceed 500 to 1,000, while 400 to 500 gives the best results. In this formula

W = width in inches,
V = rim speed in feet per minute,
$H.P.$ = horse-power to be absorbed.

Flather, in his "Dynamometers," gives K an average value of 400 for the ordinary non-compensating water-cooled brake, and 750 for the compensating type.

The power absorbed by a friction brake is measured by the resistance it offers to the rotating shaft. This equals the product of the force, W, which opposes the rotation of the brake lever at the distance L from the center of the brake wheel, multiplied by the linear speed of this point of resistance if it rotated with the brake wheel. From this it is evident that the diameter of the brake wheel, or the coefficient of friction does not enter into the calculations for horse-

power. This will be made clearer, perhaps, by the following analysis:

Let

W = net pull in pounds at the end of the brake arm,

w = net pull in pounds at the rim of the brake wheel,

L = effective length of the arm, from the center of the brake wheel to the point where the pull is measured,

r = radius of the brake wheel, to friction surface,

N = number of revolutions per minute, by the wheel.

The velocity V of the friction surface of the wheel in feet per minute will be

$$3.1416 \times 2r \times N$$

and the foot-pounds per minute absorbed by the friction will be

$$3.1416 \times 2r \times N \times w =$$

foot-pounds per minute.

Now the pull w at the wheel rim is equal to the pull W at the end of the arm multiplied by the ratio of arm length L to wheel radius r; thus:

$$w = W \times \frac{L}{r}.$$

Substituting this equivalent in the foot-pounds formula: Foot-pounds per minute =

$$3.1416 \times 2r \times N \times W \times \frac{L}{r},$$

and as the two r's cancel out, foot-pounds per minute =

$$6.2832 \times N \times W \times L.$$

$$H.P. = \frac{6.2832\,N\,W\,L}{33{,}000},$$

which may be also written

$$H.P. = k\,N\,W,$$

in which

$$k = 0.0001904 \times L.$$

The horse-power calculations are greatly facilitated if a value for L is chosen which will make k a decimal with only one significant figure. Thus, where

$L = 5.252$ feet, or 63⅛ inches, $k = 0.001$,

$L = 3.676$ feet, or 44⅛ inches, $k = 0.0007$,

$L = 2.626$ feet, or 31 9-16 inches, $k = 0.0005$.

The 63⅛-inch lever arm is ordinarily used for horse-powers between 100 and 250 at moderate speeds, while, with very low speeds or greater horse-powers the arm should be correspondingly longer. At the lower horse-powers the speeds vary between wider limits, and this, as well as the horse-power, governs the length of the arm, which should decrease with the former and increase with the latter. The 31 9-16-inch arm has been used with good results for horse-powers between 5 and 40 at speeds under 300 revolutions per minute, and up to 75 horse-power at speeds above this. Needless to say, these directions are merely approximate, and are only intended to afford a general guide to the selection of an arm length which will bring W within reasonable limits for reading.

The pressure of the brake arm on the scales is greater than the value W entering into the calculations by an amount equivalent to the unbalanced weight of the arm. Sometimes this is counterbalanced by suspending a weight at the short end of the arm, but more often by weighing the unbalanced pressure and making a zero correction on the scales known as the

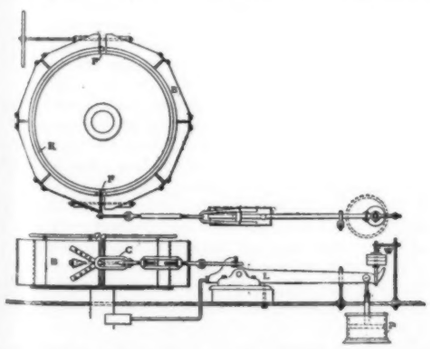

FIG. 3.—PRONY BRAKE FOR VERTICAL-SHAFT MOTORS.

brake constant or "tare." One way to ascertain this value is to loosen the brake so that it will hang freely from a knife edge inserted between the top of the brake and the rim of the wheel and at a point vertically above the center of the wheel.

Motors having a vertical shaft cannot make use of the Prony brake in its usual form. Fig. 3 shows how the Holyoke Water Power Company, of Holyoke, Mass., transfers the horizontal torque of the brake B to a vertical plane by means of the link C and bell-crank lever L, and balances the pull by an adjustable weight W on its end. The brake strap consists of hard wood blocks with spiral grooves and is kept in place by the lower external flange on the rim of the pulley. Cooling water is supplied to the external rim of the wheel through pipes E and sprayed at F, although it is often necessary to substitute strong soap suds to prevent severe vibrations. A shield of canvas intercepts the spraying liquid thrown from the surface of the wheel, and it is collected into the wheel pit below. It is seldom possible to use this brake without the dashpot P to check the vibrations.

The principal disadvantages in the use of the Prony brake in extended commercial testing are the uncer-

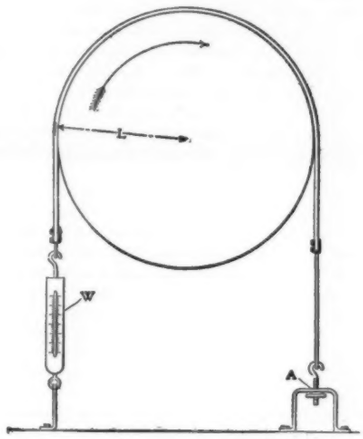

FIG. 4.—STRAP BRAKE.

tainty incident to the vibrations, which are so difficult to eliminate, and the constant attention required to keep the load constant. These become more serious with an increase in the number of testing stands in continual use, as in a factory which turns out a large number of small units, since the labor item will be a large percentage of the cost of testing. The advantages are the low initial cost of the equipment, its adaptability to different types of motors, and its simplicity.

STRAP AND ROPE BRAKES.

Other forms of friction brake having essentially the same style brake wheel as the Prony brake, but provided with a flexible band or rope in place of the brake blocks and extension arm, are used to a limited extent. The strap brake, illustrated in Fig. 4, is used for very small powers. The Prony brake formula for calculating power is used, W being read on the spring balance, and L being equal to the radius of the brake wheel plus half the thickness of the brake strap. The material of the strap is usually leather free from stickiness, but it may also be prepared canvas, or other material. The load adjustment is at A.

With a typical rope brake, its chief advantage lies in the ease with which it can be applied to the fly-wheels of certain motors without any provision for water cooling. A very steady load may be obtained with a wheel-rim speed as high as the requirements of safety will allow in a fly-wheel, reaching 8,000 to 9,000 feet per minute. This is an advantage over the Prony brake, but it will be readily seen that for the same horse-power the higher speeds demand fly-wheels of smaller diameter than with the lower speeds, and consequently the value L, which depends on the radius of the wheel, is less, while the weight and strain on the rope and balance are correspondingly greater. At low speeds and horse-powers the heat-radiating surface per horse-power is large enough to make water cooling unnecessary. With wheel rims of greater width, the number of turns of rope in parallel may be increased by using a suitable equalizing device and this reduces the pressure of any one rope on the wheel.

This will allow a greater horse-power to be absorbed before the rope begins to char at its point of maximum pressure. In general, water cooling will be found advisable if the revolutions per minute times the horse-power exceeds about 15,000, unless a multiplicity of ropes, balances, or a complicated equalizing device is used. Ropes as large as can be conveniently handled, say from .1 inch to 1½ inches, usually give better and longer service than smaller ones. Little lubrication is needed, but occasionally smearing the rope with grease has been known to give good results.

Although the rope tension is usually obtained by suspending a weight from the free end and read by a spring balance at the upper end, the adaptability of the arrangement represented in Fig. 5 will be readily appreciated. The difference between the tensions at the two ends of the rope measures the effective pull and is recorded by scales on the platform of which the standard J is placed. To the cross arm at the top of this standard are fastened the hook bolts over which the bights of the ropes are looped; the ends of the ropes are clamped to a cross bar which equalizes the strains when a weight is suspended at its center. In absorbing small loads at low speed, regulation is obtained by providing the hooks H with adjusting screws on their shanks, but with higher speeds, necessitating a smaller pulley, the writer found that the strain on these adjusting screws becomes so great that sensitive regulation can only be obtained by making the pull on the free ends of the rope adjustable. This was provided for by replacing the suspended weight with a rope R, passing under the pulleys in the base of the standard and fastened to a finely threaded adjusting screw A conveniently mounted in the other end of the cross arm. Excellent regulation was obtained in this way.

The standard and scales must be placed so that the pull is vertical and the scales platform level. The brake constant or zero correction equals the weight of the standard and its fittings plus the weight of a section of the rope. To find its value, weigh it with the adjusting screw A loosened up until the ropes hang free from tension, but in their normal position.

The same formula is used for calculation of power as with the Prony brake, but L is equal to the radius of the wheel plus half the diameter of the rope. Owing to wear and stretch of the rope, the distance between the center line of tension of the rope and the surface of the brake wheel is uncertain, but is taken as the radius of the rope. With high-speed motors and small wheels the error will probably not exceed one per cent. With low-speed motors it is negligible.

The chief advantages of the rope brake lie in its low first cost and ready adaptability to testing certain small and medium sized units, giving it a decided advantage even over the Prony brake within the specified limits. It, of course, requires the constant attention of the tester and a frequent renewal of ropes is necessary.

Numerous self-adjusting friction brakes designed to keep the load constant automatically by changing the pressure of the brake strap, have been invented; but with one or two exceptions the added application in the hands of an inexpert mechanic does not seem to warrant general adoption in commercial work.—Power.

COMPARISON OF THE FOREIGN-BORN POPULATION IN THE ORIGINAL AND ADDED AREAS.

APPROXIMATELY two-thirds of the 2,250,000 foreign-born enumerated in 1850 were reported as residing in the area covered by the First Census. Twenty years later the added area passed the original area in proportion of foreign born. In 1900 the proportions were, original area, 48.5 per cent, added area 51.5 per cent. Should the Thirteenth Census show the proportionate increase for both areas which was shown from 1890 to 1900, the area enumerated in 1790 will once more in 1910 report an excess of the foreign-born population. Although the original area was apparently maintaining a gratifying increase in population, much of this increase is due to the accession of foreigners; large numbers of immigrants arriving in the United States remain in the seaboard cities or in the older States, attracted by the magnitude of industrial operations and dense population. In the older sections of the republic the proportion of children in the native white population is lower than elsewhere; hence, while the inhabitants of the older States continue to increase in number to a degree which gratifies local pride, the composition of the population appears to be undergoing a rapid and significant change.

The Southern States which form a part of the original area have been practically silent partners so far as the subject of foreign born population is concerned. Persons of foreign birth continue to be practically a negligible element in the Southern States, but their numbers had increased in 1900 to nearly 5,000,000 in New England and the Middle States. The foreign-born and native-born of foreign parents in New England and the Middle States together formed more than half of the entire white population in 1900 (518 in every thousand of white persons), but in the Southern States formed but 79 in every thousand.

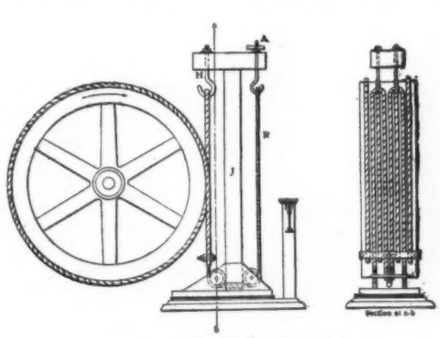

FIG. 5.—ROPE BRAKE.

UNDERGROUND TEMPERATURE AND RADIUM.

IS THE ONE DUE TO THE OTHER?

BY PROF. JOHN JOLY, M.A., F.R.S.

IT would be a matter of the highest interest if we could definitely connect the rise of temperature which is observed in deep borings and tunnels with the radio-activity of the rocks. We are confronted, however, by the difficulty that our deepest borings and tunnels are still too near the surface to enable us to pronounce with certainty on the influence of the radium met with in the rocks. This will be understood when it is remembered that a merely local increase of radio-activity must have but little effect upon the temperature unless the increase be of a very high order indeed. A clear understanding of this point shows us at once how improbable it is that volcanic temperatures can be brought within a very few miles of the surface by local radio-activity of the rocks. To account on such principles for an elevation of temperature of, say, 1,200 deg. at a depth of three or four miles from the surface, a richness in radium must be assumed far transcending anything yet met with in considerable rock masses; and as volcanic materials appear to show nothing of such exceptional richness in radium, we can hardly suppose local radio-activity of the upper crust responsible for volcanic phenomena.

When we come to apply calculation to results on the radio-activity of the materials penetrated by tunnels and borings, we at once find that we require to know the extension downward of the rocks we are dealing with before we can be sure that radium will account for the thermal phenomena observed. At any level between the surface and the base of a layer of radio-active materials—suppose the level considered is that of a tunnel—the temperature depends, so far as it is due to local radium, on the total depth of the rock-mass having the observed radio-activity. This is evident. It will be found that for ordinary values of the radium content it is requisite to suppose the rocks extending downward some few kilometers in order to account for a few degrees in temperature at the level under observation. There is, of course, every probability of such a downward extension. Thus in the case of the Simplon massif the downward continuance of the gneissic rocks to some few kilometers evokes no difficulties. The same may be said of the granite of the Finsteraarhorn massif and the gneisses of the St. Gothard massif, materials both of which are penetrated by the St. Gothard tunnel, and which appear to possess a considerable difference in radio-activity. In dealing with this subject, comparison of the results obtained at one locality with those obtained at another is the safest procedure. We must accordingly wait for an increased number of results before much can be inferred. I will now lay the cases of the two great tunnels as briefly as possible before you. And first as to the temperature effects observed in the two cases.

The Simplon tunnel for a length of some seven or eight kilometers lies at a mean distance of about 1,700 meters from the surface. At the northerly end of this stretch the rock temperature attains 55 deg., and at the southern extremity has fallen to about 35 deg. The temperature of 55 deg. is the highest encountered. The maximum predicted by Stapff, basing his estimates on his experience of the St. Gothard tunnel, was 47 deg. Other authorities in every case predicted considerably lower temperatures. Stockalper, who also had experience of the St. Gothard, predicted 36 deg. at a depth of 2,050 meters from the surface, and Heim 38 deg. to 39 deg.†

When the unexpectedly high temperatures were met with, various reasons were assigned. Mr. Fox has suggested volcanic heat. Others point to the arrangement of the schistosity and the dryness of the rocks, where the highest temperatures were read. The latter is evidently to be regarded more as explanation of the lower temperatures at the south end of the tunnel, where the water circulation was considerable, than of the high temperatures of the northern end. The schistosity may have some influence in bringing the isogeotherms nearer to the surface; however, not only are the rocks intensely compact in every direction, but what schistosity there is by no means inclines in the best directions for retention of heat. From the sections the schistosity appears generally to point upward at a steep angle with the tunnel axis.‡

Where there is such variability in the temperatures, irrespective of the depth of overlying rock, there is difficulty in assigning any significant mean gradient. The highest readings are obviously those least affected by the remarkable water circulation of the Italian side. The higher temperatures afford such gradients as would be met in borings made on the level—about 31 meters per degree.

The temperatures read in the St. Gothard rocks were of a most remarkable character. For the central parts of the tunnel the gradients come out as 46.6 meters per degree. Stapff, who made these observations and conducted the geological investigations, took particular pains to ascertain the true surface temperatures of the rock above the tunnel; and from these ascertained temperatures, the temperatures in the tunnel rock and the overlying height of mountain, he calculated the gradients.

But this low gradient is by no means the mean gradient. At the north end, where the tunnel passes through the granite of the Finsteraarhorn massif, there is a rise in the temperature of the rock sufficient to steepen the gradient to 20.9 meters per degree. Stapff regarded this local rise of temperature as unaccountable save on the view that the granite retained part of the original heat. This matter I will presently return to.

Now, it is a fact that the radium-content of the Simplon rocks, after some allowance for what I have referred to as sporadic radium, stands higher than is afforded by the rocks in the central section of the St. Gothard, where the gradient is low. For the Simplon the general mean is (on my experiments) 7.1 billionths of a gramme per gramme. This mean is well distributed as follows:

Jurassic and Triassic altered sediments...	6.4
Crystalline schists, partly Jurassic and Triassic, partly Archæan	7.3
Monte Leone gneiss and primitive gneiss..	6.3
Schistose gneiss (a fold from beneath)...	6.5
Antigorio gneiss	6.8

The divisional arrangement is Prof. Schardt's. Forty-nine typical rocks are used in obtaining these results, and the experiments have been in many cases repeated on duplicate specimens. Including some very exceptional results, the mean would rise to 9.1×10^{-12} grammes per gramme.

Of the St. Gothard rocks I have examined fifty-one specimens selected to be, as far as attainable, representative.*

Of these, twenty-one are from the central region, and their mean radium content is just 3.3. The portion of the tunnel from which these rocks come is closely coincident with Stapff's thermal subdivision of regions of low temperature.† This portion of the mountain offers the most definite conditions for comparison with the Simplon results. The region south of this is affected by water circulation; the regions to the north are affected by the high temperature of the granite.

We see, then, that the most definite data at our disposal in comparing the conditions as regards temperature and radio-thermal actions in the two tunnels appear to show that the steeper gradient is associated with the greater radium-content.

It is possible to arrive at an estimate of the downward extension of the two rock masses (assumed to maintain to the same depth their observed radio-activity), which would account for the difference in gradient. In making this estimate, we do not assume that the entire heat-flow indicated by the gradients is due to radium, but that the difference in radium-content is responsible for the difference of heat-flow. If some of the heat is conducted from an interior source (of whatever origin), we assume that this is alike in both cases. We also assume the conductivities alike.

Calculating on this basis, the depth required to establish on the radium measurements the observed difference in gradients of the Central St. Gothard and of the Simplon, we find the depth to be about 7 kilometers on the low mean of the Simplon rocks, and 5 kilometers on the high mean. There is, as I have already said, nothing improbable in such a downward extension of primitive rocks having the radio-activities observed; but as a different distribution of radium may, of course, obtain below our point of observation, the result can only claim to be suggestive.

Turning specially to the St. Gothard, we find that a temperature problem of much interest arises from the facts recorded. The north end of the tunnel for a distance of 2 kilometers traverses the granite of the Finsteraarhorn massif. It then enters the infolded syncline of the Usernmulde and traverses altered sediments of Trias-Jura age for a distance of about 2 kilometers. After this it enters the crushed and metamorphosed rocks of the St. Gothard massif, and remains in these rocks for 7½ kilometers. The last section is run through the Tessinmulde for 3 kilometers. These rocks are highly altered Mesozoic sediments.

I have already quoted Stapff's observations as to the variations of gradient in the northern, central, and southern parts of the tunnel. He writes: "They (the isotherms) show irregularities on the south side, which clearly depend on cold springs, they bend down rapidly, and then run smoothly inclined beneath the water-filled section of the mountain. Other local irregularities can be explained by the decomposition of the rock; but there is no obvious explanation of the rapid increase in the granite rocks at the northern end of the tunnel (2,000 meters), and it is probably to be attributed to the influence of different thermal qualities of the rock on the coefficient of increase. For the rest these 2,000 meters of granite belong to the massif of the Finsteraarhorn, and, geologically speaking, they do not share in the composition of the St. Gothard. Perhaps these two massifs belong to different geological periods (as supposed for geological reason long ago). What wonder, then, if one of them be cooler than the other." (*Loc. cit.*, p. 30.)

Commenting on the explanation here offered by Stapff, Prestwich* states his preference for the view that the excess of temperature in the granite is due to mechanical actions to which the granite was exposed during the upheaval of this region of the Alps.

The means of radium-content in the several geological sections into which the course of the tunnel is divisible are as follows:

Granite of Finsteraarhorn.....	7.7
Usernmulde	4.9
St. Gothard massif.....	3.9
Tessinmulde	3.4

The central section, however, if considered without reference to geological demarkations, would, as already observed, come out as barely 3.3. And this is the value of the radio-activity most nearly applicable to Stapff's thermal subdivision of the region of low temperature.

If we accept the higher readings obtained in the granite as indicative of the radio-active state of this rock beneath the Usernmulde, a satisfactory explanation of the difference of heat-flow from the central and northern parts of the tunnel is obtained. Using the difference of gradient as basis of calculation, as before, we find that a downward extension of about 6,000 meters would account for the facts observed by Stapff, if the outflow took place in an approximately vertical direction. This depth is in agreement with the result as to the downward extension of the St. Gothard rocks as derived from the comparison with the Simplon rocks.

We are by no means in a position to found dogmatic conclusions on such results; they can only be regarded as encouragement to pursue the matter further. The coincidence must be remarkable which thus similarly localizes radium and temperature in roughly proportional amounts, and permits us, without undue assumptions, to explain such remarkable differences of gradient. There is much work to be done in this direction, for well-known cases exist where exceptional gradients in deep borings have been encountered—exceptional both as regards excess and deficiency.

Fr. Reinold has taken out a German patent for a process for making artificial stone from the sifted ashes obtained by burning household rubbish, employing as a binder a pulp made of the wood, paper and similar ingredients of the rubbish. Artificial stone has already been made by combining burned rubbish with cement, but a large quantity of cement is required, and the mass sets so quickly that only a small quantity can be mixed at a time. The manufacture of papier maché from ashes and paper pulp requires ashes of special quality and the addition of paste as a binder. In the new process the composition is made entirely of materials contained in the rubbish.

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* Abstracted from paper read before the British Association for the Advancement of Science.

† See the account given by Schardt, Verhandl. Schweizerischen Natur. Gesellsch., 1904, lxxxvii, "Jahresversammlung," p. 204 et seq.

‡ Schardt, loc. cit.

* I would like to express here my acknowledgments to the trustees of the British Museum for granting me permission to use chips of the rocks in their possession; and especially to Mr. Prior for his valuable assistance in selecting the specimens.

† Trans. North of England Mining and Mec. Engineers, xxxiii, p. 25.

* Proc. R. S., xii, p. 44.

THE PROPERTIES OF MATTER.

SIR JOSEPH J. THOMSON'S VIEWS.

THIS year, as the subject of his course of lectures at the Royal Institution, Prof. Sir Joseph J. Thomson, F. R. S., has chosen "The Properties of Matter." In opening his discourse, Prof. Thomson said that in this, his first lecture, he proposed to consider the structure of matter; his second lecture would deal with the properties of matter when in rapid motion; his third with such universal properties of matter as gravitation; and his fourth, fifth, and sixth with matter in the solid, liquid, and gaseous state respectively. As for the structure of matter, almost from the time when men first began to speculate about natural philosophy, the idea, Prof. Thomson said, had been held that matter was not continuous and homogeneous. The opposite view—that it possessed the properties of continuity and homogeneity—had never, he went on, had any real influence on physics. This particular view had, indeed, been more prevalent some ten years ago than ever before in the history of science. It was not, nevertheless, an easy matter to give a satisfactory and really rigid proof of the non-uniformity of matter. According to the atomic theory, now almost universally accepted, matter as we knew it was built up of an extremely large number of very small particles, separated by a medium differing entirely from these particles in its properties, which medium was known as the ether. What led to the atomic theory in the first place was the fact that bodies could be compressed, which received a natural explanation if they consisted of small particles separated by empty space. In that case the pressure simply pushed the particles closer together. Again, the fact that one body could be penetrated by another could also be accounted for on the same hypothesis. In a previous course of lectures, the speaker continued, he had shown the penetration of matter by particles shot off at great velocity by electrical means. On the present occasion he would, he said, use electrical means merely to detect this penetrability. Using a piece of apparatus consisting of a vacuum bulb, having a branch to it in the shape of a small platinum tube, the lecturer showed that on heating this tube in a Bunsen flame the character of the discharge through the vacuum tube was entirely altered, due, he said, to the passage of hydrogen from the flame through the incandescent platinum.

In a similar way, he proceeded, sodium could penetrate glass, and this fact had proved extremely useful when it was desired to remove the last traces of oxygen from a vacuum tube. Sodium could be sent through from the outside, and it then absorbed the residual oxygen. Quite recently, moreover, it had been proved that other elements could also find their way through glass, a circumstance which had a very important bearing on the experiments made some time ago, with a view to ascertaining whether or no there was a change of weight in chemical combinations. If the glass vessels used in these researches were not absolutely impervious to the reagents, matter might be lost by actual passage through the glass. Bellati, an Italian physicist, had moreover shown that hydrogen could penetrate a considerable thickness of iron even in the cold. All these instances of the penetration and compression of matter received their explanation if matter generally was full of holes, through which the other matter found its way.

If, however, we tried to divide matter to such a degree that it lost its properties, it at once became apparent that the ultimate particles were exceedingly small. Thus Faraday had obtained gold leaves only 1/10,000,000 inch thick, but these showed still the characteristic properties of gold. Again, tales were told of the scent of musk lasting for centuries in a room, though in this connection it should be noted that much depended on the degree of ventilation, and there was, in fact, a chapel in London in which he had every reason to believe the air had not been wholly changed during the last seventy years, and in such a case the scent of musk might well be retained in all its vigor. Still, even so, the long duration of the scent was a strong argument in favor of the great divisibility of matter. Mr. Strutt, moreover, had recently shown that by means of the spectroscope it was possible to detect the presence of neon in one-twentieth of a cubic centimeter of air, of which neon constitutes 1/100,000 part by volume. Hence the spectroscope could detect 1/2,000,000 of a cubic centimeter of neon. Put in this way, it might appear that the spectroscope was extraordinarily delicate, but at the same time, 1/2,000,000 of a cubic centimeter contained 10 million million molecules, a number much greater than the total population of the globe, so that if we possessed no more delicate tests than this for man, we should never have found out the world was inhabited. There was, he went on, an extraordinary difference between the difficulty of detecting non-electrified molecules, and the ease with which electrified ones could be detected. As stated, 10 million million was about the smallest number of non-electrified particles which could be detected; while, when electrified, it was possible to detect a single one.

Prof. Tait, the speaker proceeded, had given an illustration of the failure of the atomic theory. The homœopathists claim that characteristic properties of a salt remained in its twelfth dilution. That was to say, a gramme of salt was first dissolved in a liter of water. From this a single cubic centimeter was removed, and added to another liter of water, which formed the second dilution. A cubic centimeter taken from this was added to a third liter, and the process in question repeated twelve times. Some special properties were still claimed for this twelfth dilution. According to the atomic theory, however, at the seventh dilution a cubic centimeter taken at random might still contain one or two molecules of the salt, but in further dilution the chances were against any particle of the salt at all being found in the cubic centimeter taken.

To show the existence of particles much too small to be visible, the lecturer added a little dilute acid to a solution of hyposulphite of soda. The sulphur was then liberated in very fine particles, which grew steadily by accretion. At first the particles were too small to reflect light, but in a little while the solution became opalescent, shining with a delicate blue, which color, he stated, was not that of the particles liberated, but resulted from their extreme smallness, cigarette smoke being blue for the same reason. Prof. Thomson also showed that a soap-film, as the liquid drained away, became, just before breaking, so thin that it could no longer reflect light, yet nevertheless, the film still retained its characteristic properties.

It was, however, possible, he continued, to obtain matter in so thin a film that its characteristic properties failed to appear. A drop of oil floated on water would, as was well known, spread, because its surface tension was less than that of the water. Every surface film of a liquid was in a state of tension, but the oil film did not pull with the same tension as pure water, and was hence dragged out and extended by the greater surface tension of the water. If, however, the drop of oil added were sufficiently minute, the phenomenon in question did not occur, the film produced being so thin that it could not show its characteristic properties. Nevertheless, if the film was only 1/1,000,000 millimeter thick, it showed these properties in all their completeness.

A more indirect, but possibly more stringent, method of reasoning, by which the atomic structure of matter was first established, originated with Cauchy, who, observing that light of different colors traversed glass at different speeds, argued that the glass must have a structure. Spectral colors were differentiated by their wave-lengths, and glass had a different "speed limit" for each color. To enforce this limit it must possess some kind of scale with which to distinguish between the different wave-lengths; and were the glass structureless and continuous, one part of it exactly the same as another, it could not differentiate between the different colors. Hence, Cauchy argued, it must possess a structure. Unfortunately for his argument, however, light had a period as well as a wave-length, so that the scale by which the glass differentiated between lights of different colors might be in time rather than in length. In fact, it was now known that the dispersion of light in passing through glass was due to the latter possessing a "structure in time." That such a "structure in time" might have a great effect on the transmission of impulse, Prof. Thomson, showed by means of Kelvin's "wriggler," which consisted of a series of laths fixed at their centers to, and equally spaced upon, a wire, one end of which was suspended from the ceiling of the lecture hall. The lecturer showed that if the lowest lath were rapidly vibrated in a horizontal plane about its center, only the laths immediately above it were affected, no impulse traveling up the wire to the top; while if the rapid vibration of the lowest lath was replaced by a slow one, the whole string took up the motion, the oscillations of the topmost being equal in amplitude to those of the lowest.

Resuming, the lecturer said Cauchy's argument was applicable to other phenomena free from the ambiguity involved in the case of the dispersion of light. He showed that the broken filament of an ordinary incandescent lamp, if set in vibration, continued to oscillate for a long period, but on admitting air to the bulb, became almost dead beat. To restore its freedom of vibration, the vacuum must, he said, be re-established, and the pressure at which the damping vanished varied enormously with the size of the vessel. The larger the vessel the lower must be the pressure before the vibration would be maintained. In a very small vessel a reduction of the pressure to 1/10 or 1/15 atmosphere sufficed, but in an ordinary lamp bulb it must be reduced to 1/100,000. Hence it appeared that gas behaved one way in a small and another way in a large vessel. Cauchy's argument was therefore applicable, and the gas must possess some scale to distinguish between the two.

Matter being endowed with a structure, it was necessary to find some means of estimating the size of its ultimate particles. This had first been done by Thomas Young about a hundred years ago, whose investigations, though published in the Proceedings of the Royal Institution, had been entirely forgotten till unearthed quite recently by Lord Rayleigh. Thomas Young was the first to give a numerical estimate of the size of the atoms and of the distance over which they could influence each other. His method was based on the fact that water possessed a surface tension, so that to increase the surface of a given mass of fluid required an expenditure of energy. Young imagined a rod of liquid, and that then this rod was pulled in two, just like a test-bar. By such a process the extent of surface was increased by twice the original cross-section of the rod. The value of the surface tension being known, the energy thus added to the liquid was also known. Young assumed that this energy was derived from the tension needed to pull the block in two, multiplied by the least distance at which the two surfaces of separation were distinct. It might, Prof. Thomson continued, be thought that water had very little tensile strength, the phrase "weak as water" being proverbial, and hence very little energy would be needed to divide the rod. Young, however, estimated the traction needed as 20,000 atmospheres, or as much as the tensile strength of the strongest steel as usually determined. This estimate of Young's was remarkably far-sighted, since it was now known from experiment that water had a considerable tensile strength, viz., 10,000 atmospheres, or half Young's estimate. To illustrate the tensile strength of fluids Prof. Thomson showed a barometric tube 45 inches long completely filled with mercury by Lord Rayleigh five years ago, and in which the liquid still remains suspended from the top of the tube by its own tensile strength. He also showed Berthelot's experiment, in which a sealed tube almost filled with alcohol, at ordinary temperatures, is heated until by the expansion of the fluid the alcohol completely fills the tube. On subsequently cooling the alcohol still completely fills the tube for a considerable time, and gives way finally quite suddenly. In making a preliminary experiment that morning the lecturer mentioned that the tension of the liquid had been sufficient to crush the tube containing it.

Returning to Young's method of estimating the intra-molecular distance, Prof. Thomson said that if p were the liquid tension, and d the least distance at which the molecules could influence each other, the work done (per unit area of cross-section) in separating the rod of liquid was $p\,d$, while the surface energy of the fluid was increased by the amount $2\,t$ per unit of cross-section, where t was the known value of the surface tension. Hence, equating the work done to the increase of energy, we had

$$p\,d = 2\,t,$$

and from this Young concluded that the distance between the molecules was 1/250,000,000 of an inch. The value now generally taken as the distance at which one particle could exert an influence on another was, he said, 10^{-8} centimeters.—Engineering.

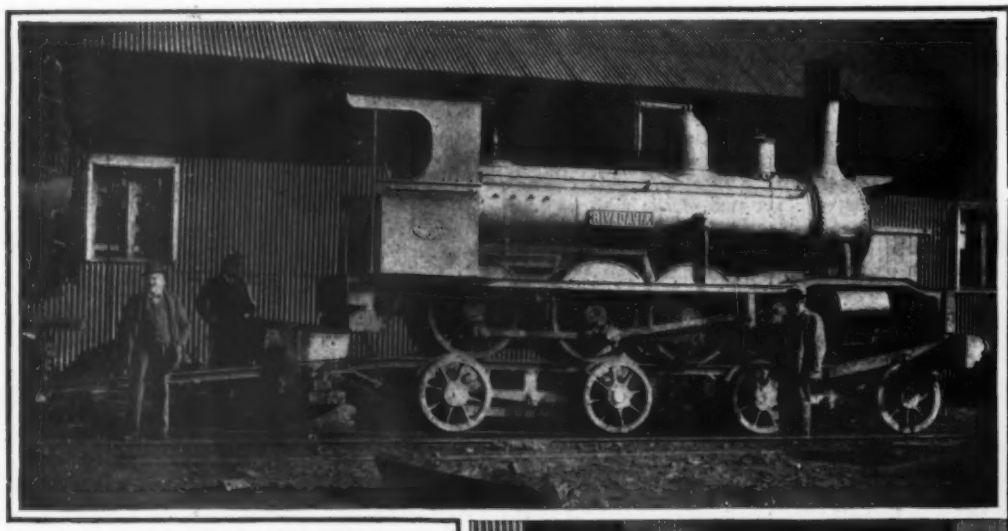
A society for the extermination of vermin has been formed in England. At the first annual meeting Sir James Crichton-Browne stated that there was one rat to every acre in England and Wales, and that each rat did damage to the extent of one farthing every day, making a total loss in a year of £15,000,000 ($75,000,000). Besides the material damage, rats brought about disease and death in innumerable cases. Sir James, after showing what had been done in Denmark, spoke of the importance of the extermination of rats in India, where it had been established that they and other vermin, more especially fleas, were largely responsible for the spread of the plague. The stomach of a flea had been found capable of holding 5,000 plague germs. It was of importance to prevent the landing of rats from ships. Sir Charles MacLaren announced that he had introduced in Parliament a bill for the extermination of rats.

A NOVEL NARROW-GAGE ROAD.

HANDLING NARROW-GAGE STOCK ON BROAD-GAGE ROADS.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE difficulties of handling narrow-gage rolling stock loaded with through freight over sections of broad-gage railroads where mixed systems prevail, or *vice versa*, are well known to every railroad engineer. In the majority of instances it involves breaking bulk at the junctions of the two varying systems, which operation not only means increased cost of transportation, but causes pronounced delays. In Chile, however, these difficulties are ingeniously surmounted on the Coquimbo section of the state railroads. This section is made up of short stretches of both narrow and broad-gage tracks. From Coquimbo to Puntilla, a distance of some 58 miles, is the broad 5-foot 6-inch gage, while from Puntilla to Oralla is the meter gage extending from the latter point to Paloma about 16½ miles and thence on to San Marcos a further 25 miles. This last-named stretch is not yet finished, but the material is being brought to Paloma for completing the line.



NARROW-GAGE ENGINE ON BROAD-GAGE TROLLEY FOR TRANSPORTATION OVER BROAD-GAGE SECTION OF THE COQUIMBO CHILIAN STATE RAILROAD.

The freight destined for any point on the narrow-gage section is loaded on broad-gage cars at Coquimbo and the latter are hauled to the terminus of the broad-gage line at Puntilla. Here instead of transferring the freight into narrow-gage cars, a low trolley is brought into service. The deck of this trolley carries throughout its length a section of track corresponding to the broad gage, and the loaded broad-gage cars, with their freight intact, are run up an incline on to this trolley where they are made fast and thus hauled over the narrow-gage sections to their destination. The railroad authorities have four of these trolleys and the time occupied in loading them in this manner occupies no more than 15 minutes. This operation is repeated three or four times a day, and it will be realized that it involves the minimum of delay and expense. When the cars have discharged their freight they either take on a return consignment or are hauled back empty to Puntilla, released, and run down the incline again on to the broad-gage track. Considerable traffic is carried on in this ingenious manner, especially between Puntilla and Oralla, where the broad-gage cars are loaded principally with copper ores brought down from the neighboring mines.

In the accompanying photographs the method of transporting a narrow-gage locomotive over the broad-gage section is shown and it illustrates the simple method by which the task is accomplished. This particular trolley is mounted on two bogies that originally formed part of the first broad-gage railroad engine dispatched to Coquimbo in 1861. These bogies did not answer their purpose satisfactorily, for owing to the numerous sharp curves, derailments were of frequent occurrence. These bogies were thus discarded in favor of two single bogies. The abandoned bogies, however, were turned to the useful purpose shown and serve to accomplish valuable work in transporting the narrow-gage engines from the meter gage railroad when repairs are requisite, since Coquimbo is the only place where locomotive overhauling can be effected. The engine was run down to Puntilla on the narrow-gage track, the tender there detached and the front part run up the incline onto the deck of the trolley. At the junctions of the two systems side tracks of broad gage with the meter gage within are laid down to facilitate transference from trolley to either track.

By this method fifteen engines have been carried from Puntilla and back, and despite the large amount of traffic that is handled in this ingenious manner both on the broad and narrow gage sections of the railroad, there has never been the slightest mishap. This trolley is used for the transportation of weights up to as much as 44 tons.

A similar example of such intercommunication is in vogue in the English Midlands, where the trunk standardized railroad system effects a junction with a narrow-gage light railway. Formerly considerable delay occurred at the junction of the two gages in transshipping freight, but narrow-gage trolleys having a short length of standard track on the deck have been successfully introduced. The design is somewhat different from that used in Chile, since the track on the trolley is placed only a few inches above the ground, outside the narrow-gage track wheels, the idea being to secure a very low center of gravity. In this manner is handled the whole of the produce consigned to stations on the narrow-gage light railway. At the various stations upon the latter system short lengths of sidetrack of the standard gage are laid down, so that the carried cars can be tracked and thus releasing the trolley, being taken on again when loaded or ready for return to the standard system.

SYSTEM OF LOADING. SHOWING INCLINE LEADING UP TO NARROW-GAGE TRACK ON DECK OF BROAD-GAGE TROLLEY; ALSO THE TWO TRACKS WITHIN EACH OTHER TO FACILITATE TRANSFER FROM TROLLEY TO EITHER SYSTEM.

A NOVEL NARROW-GAGE ROAD.

TESTING SAMPLES OF CAR PAINTING.

ABOUT this time of the year every large railway system begins overhauling its open summer cars, and the question arises of how much to spend on painting and varnishing. The cost of painting cars depends very largely on the methods employed. Some are much more expensive than others, and it is possible to spend as much as $50 per car or as little as $5. From a study of specifications alone, it is not easy for the executive officer who must decide on the expenditures to be made to determine what method will produce the best results for the least money. One large city system in the East solved this difficulty by taking four cars of the same type and same general conditions and repainting them with different methods. One car was scraped to the wood, all paint burned off and was completely repainted and varnished, giving it the appearance of a new car. This cost $40. Another car had the paint freshened up with a paint-cleaning compound and the varnished parts coated with a special oil mixture of about the same composition as ordinary varnish, but not boiled. This cost only $5.50. The two other cars were partially repainted and varnished with different degrees of thoroughness. These four sample cars when completed were submitted to the general manager for a decision as to which method to adopt for the remaining cars. The appearance of the car which cost only $5.50 to refinish was so favorable, that the cheap method will be followed this year in overhauling the several hundred open cars operated by this company. Without a sample before him, the general manager would have found it hard to believe that a car could be put in good condition, so far as painting was concerned, for such a small expense, and in this particular case the manager believed from his experience that there was not enough difference in durability between the two methods to warrant the additional cost. The practice of another road to test the durability of two different makes of varnish is to varnish half of the main panel of a car with one kind and half with the other. In this way both are subject to the same conditions, and the wearing qualities are evident.—Electric Railway Journal.

A notable piece of engineering is illustrated in the Iron Age in connection with a bridge which has been erected over the Chicago River for the Chicago & Northwestern Railway. The bridge is of the Strauss trunnion bascule type, and is said to be not only the largest bridge of this design, but also the heaviest double-track, single-leaf, bascule bridge in the world. The length of the bascule is 170 feet from the center of the trunnion to the center of the front end floor beam, there being in addition a 25-foot 9-inch deck plate girder span. When the bascule is swung, the load of the leaf when moving is carried on two hollow 28-inch shafts, or trunnions, mounted on a skeleton tower at a height of about 36 feet above mean water level. The weight of the leaf is counterbalanced by a reinforced concrete block weighing 1,200 tons, and centrally mounted on 12-inch pins in the tail end of the trusses. The live load is not carried on the trunnions, but on two independent supports 26 feet in front of it. The bridge is operated by two struts, pin connected to the top chord, having racks meshing with pinions placed on the top of the tower. These pinions are driven by a pair of 50-horse-power electric motors, with 500-volt direct current. The motors are provided with solenoid brakes, and also an emergency brake operated by either hand or power.

CALIGULA'S GALLEYS IN THE LAKE OF NEMI.*

A ROMAN EMPEROR'S WHIM.

BY ST. CLAIR BADDELEY.

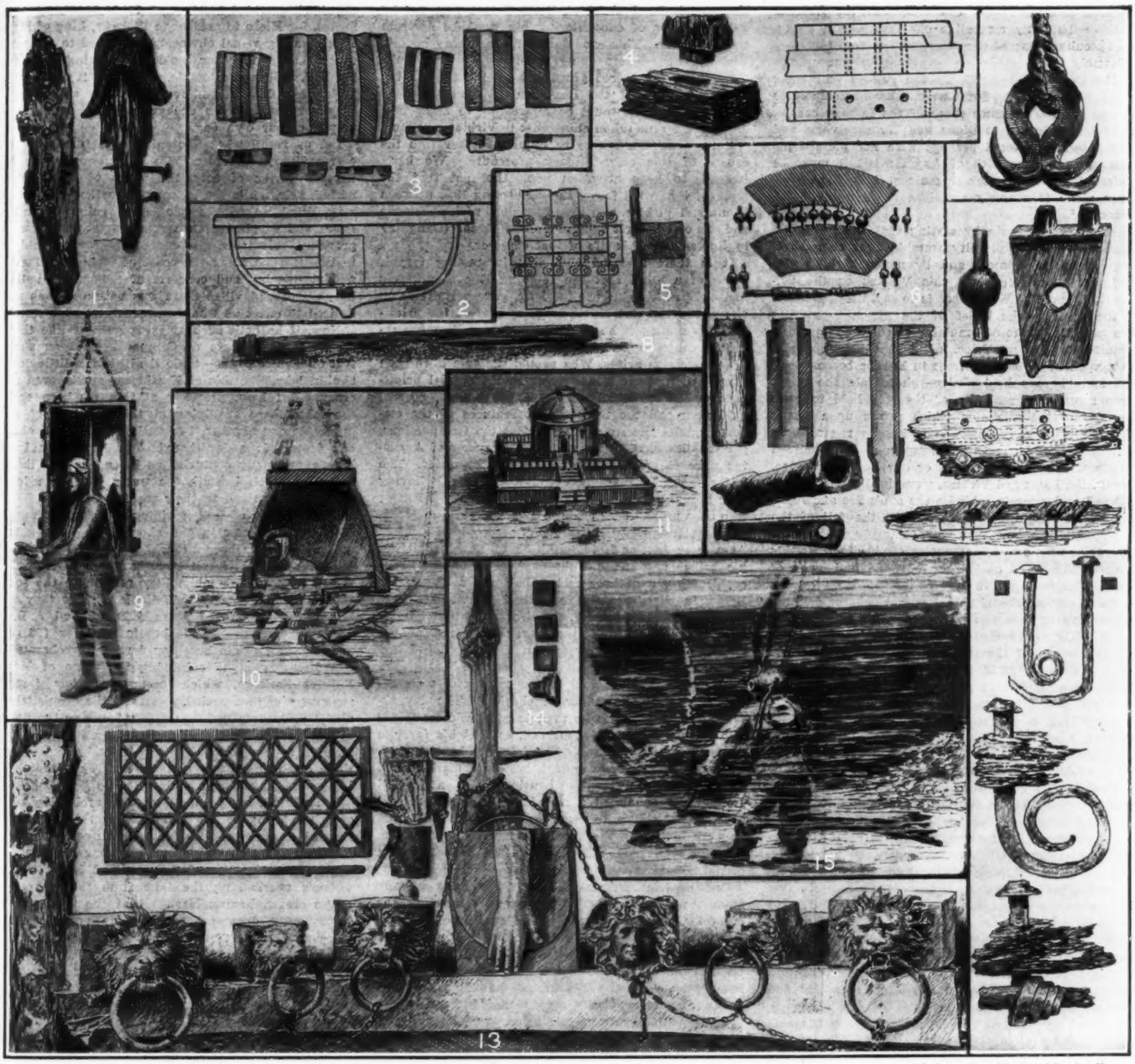
THERE are even in Italy few so beautiful spots as the Lake of Nemi. Situated in a deep crater dating from one of the more ancient of five periods of eruption attributed by geologists to the Alban Mountain, it has been likened to a cup with wine glimmering in its depth; and the woods of Ilex around it, to a sacred wreath around the cup. It is a still sheet of water framed in by magnificent gray crags rimmed with dark evergreens, and so completely does silence reign, that during many hours lately spent there, except for the occasional stir of the trees, were heard only two sounds—the deep-tongued bells of Genzano and the croaking of a pair of ravens. Ridge upon ridge above it the forests (formerly the hiding-place of Gasperone) rise up to Monte Cavo, like steps placed there for the gods leading down to this enchanted pool—for ages consecrate to Diana, and still called by the simple country folk 'Lo Specchio di Diana," or the mirror of Diana. It measures but a mile and a quarter across, and four miles in circumference. It is drained off into the western Campagna, and to the sea beyond that, by an ancient "emissarium," or tunnel, 1,640 yards in length, the precise age of which is not yet ascertained.

Ovid, Virgil, Propertius, all refer to it as Lacus Nemorensis, a lake (like that at Sicyon and Holran Göl), consecrated to the worship of Diana Aricina, and it is obvious that its present title of Nemi derives from its former sacred "nemus" or grove. Strabo says, "The temple of the goddess is in the grove, and the deep lake lies opposite to it. People say that the cult here derives from the Tauric cult of Diana," i. e., the Ephesian. Nevertheless, at whatsoever period it became Hellenized, the name of the Latian goddess survived.

This at once gives the position both of grove and temple. He further declares that the lake water is supplied from a source, at once visible and close to the Temple of Diana.[1] This is borne out by the presence thereby of a copious cascade, to-day known as "La Tempesta," which gushes out of the steep wooded rocks beneath the castled town of Nemi, not far from the site under consideration.

In 1885 the late Lord Savile at his own expense opened up a spacious area cumbered with ancient remains corresponding to the position described by Strabo, near the northern margin of the lake; and he was immediately rewarded by finding abundant votive offerings in terra cotta and bronze, which, beyond question, identified the situation of the "Artemisium," or Temple of Diana. Most of these terra cotta objects related to women and to this goddess. It has been possible to find many of these lying about the site until quite lately.

In some other openings, however, but little removed



Redrawn from Illustrated London News.

1. Lead plate with embedded nails and an iron-shod pawl. 2. Diver's sketch of the galleys. 3. Moldings of glazed enamel. 4. Mortise and tenon; joint secured by pins (side and plan views). 5. Reconstruction of the deck structure; plan and longitudinal section. 6. Ornamental woodwork. 7. Small roller and hinge. 8. Metal-shod beam. 9 and 10. Diving bells used during the researches of 1539. (From De Marchi's descriptions.) 11. Reconstruction of the Galley of Caligula, fram an engraving signed "Del Galle," sixteenth century. 12. Terra cotta tube (perspective and sectional views); stanchion and section of same; little latch; joint with nails and mortise. 13. Relics from the galleys. Augural hand; above it, lead pipe; to the left, grating; to the extreme left, fragments of the side of the galley covered with sheet lead; at the bottom, bronze rope-rings held in the mouths of animals. 14. Metal caps. 15. How a diver saw Caligula's galley. 16. Nails bent on being driven into knotty wood.

RELICS FROM THE ROMAN GALLEYS IN LAKE NEMI.

CALIGULA'S GALLEYS IN THE LAKE OF NEMI.

* Nineteenth Century and After.

[1] Strabo, v.

from this first excavation, were found remains of several male terra cotta statuettes. These were more or less fragmentary, and all of them in attitudes indicative of active motion.

One thing was evident, these could have had nothing to do with the essentially feminine cult of Diana Taurica. One of these figures wears around his chest a thong, or fascia, such as were worn by chrioteers. With these was found a fine votive vase, upon the body, or bowl, of which is represented, in full action, a horse race, with the "meta" (or goal), and the "ova" (eggs) representing the customary seven rounds of the circus course. Further (and that is an interesting point), four of the "ova" are displayed fallen, showing that three more rounds of the race have yet to be run. The riders are nude, and two griffons (for Nemesis) are seen seizing a stumbling horse, and tearing it. But what would such a vase be doing in precincts of Diana? How can we explain the presence of these distinctly masculine offerings within a precinct peculiarly sacred to a feminine cult?

Possibly the explanation of this may throw light on the significance of the sunken galleys still lying in the adjacent lake. Some writers have attempted to account for the presence there of the famous barges, as having pertained to Diana and her sanctuary, and having been connected perhaps with her picturesque processions on the 15th of August; but it must be confessed that, although ingenious, this hypothesis taken alone is scarcely sufficient to explain all the evidences.[2]

Let us rather begin by stating that besides Diana there was another divinity worshiped at this place, from prehistoric times; and by name, Virbius. Indeed, tradition recognized this Virbius as the primeval King of the Wood, that is to say, the tree spirit of the oak. In the belief of the Aryan races that tree was the divine accumulator of solar energy, represented by the mistletoe, or golden bough, which grew upon it. When our trees in Europe become leafless and "bare ruined choirs—where late the sweet birds sang," the real life of them is held to have passed into the mistletoe which grows upon them; and, accordingly, in later days, it was regarded as very sacred, and came to be suspended for felicitous usages at the winter solstice, or our later Christmas.

Now, the Latin god Virbius, worshiped at Nemi, was believed each year to rekindle the sun's fire and light, and he was represented there until the fall of the empire by a base-born man who, strangely enough, was regarded as his own reincarnation. Ovid describes this King of the Wood as "strong of hand and swift of foot."[3] Besides him, we hear of his priest, or Flamen Virbialis. This priestly post, however, was held in imperial days by one who conjoined with it free birth, the knightly rank, and also magisterial functions—such as "Editorship of the Games."[4] It will therefore be of no little interest if, in the future, inscriptions be found to throw further light upon the relationship of this well-born priest to the base-born "Rex." For it is a striking fact that the Flamen of Virbius who superintended his cult and sacrifices (about which unfortunately we know but little) should socially be so superior to his master. So far, it is perhaps to be explained only by the notion that the incarnated god, like the man-eating tiger, was bound to lead a degraded life.

The curious conditions pertaining to the Rex Nemorensis are now well known, largely owing to Mr. Frazer's noble volumes entitled "The Golden Bough," in which (as a text for his theory) he recapitulates the various passages in ancient authors relating to the subject.

Pausanias relates that the people of Aricia (i. e., Nemi) told him the old Greek story of Hippolytus having been brought back to life by Æsculapius, and having come from Greece to Aricia and there founded an area sacred to Diana Artemis, "where," he says, "down to my time the priesthood of the goddess is the prize of a victory in single combat. The competition is not open to free men, but only to slaves who have run away from their masters."[5]

Another peculiarity needs be recalled—namely, that no horses were permitted to approach the sacred grove here. This, as Prof. E. Pais has pointed out, was placed in relation with the very name of Hippolytus and with the Hippoi, or unlucky horses, which dragged that hero to his death. That is to say, the Aricians identified Virbius (to whom was dedicated a portion of the neighboring Via Appia, as Clivus Virbius) with the son of Theseus, just as they identified Diana with Artemis. Syncretism had done its work there; and this may have been an attempt on the part of the local authorities to account for the combined cults of Diana and Virbius at Nemi, and their correlation. The latter consisted in the fact that the "Rex," or incarnation of Virbius (doubtless the Sun God), was likewise the hereditary priest of Diana. He was the slayer who must himself be slain, and the Keeper of the Golden Bough, or mistletoe, in the sacred grove.

Now, this base-born Rex, or "Servus Rex," is without difficulty to be identified with the traditional sixth king of Rome, Servius, who established the federal temple of Diana upon the Aventine Hill, as a rallying point for the Plebs, and a sanctuary for fugitive slaves. For of him, too, we not only hear that he was born of a slave mother, and so called Servius (Tullius), but that he met his death like Hippolytus, being trampled upon by the chariot horses in a street there called Clivus Urbius (i. e., Virbius).[6] This, as Prof. Pais has demonstrated, points to the conjecture that Servius Tullius may have been the priest of Arician Diana transferred to Rome. There is evidence in Tacitus ("Annales," xiii. 8) of the dependence of the Aventine cult upon that of Aricia.

We are further informed by Strabo that the Rex Nemorensis went about at times armed with a long knife in view of encountering his would-be assassin and successor. This candidate for sanguinary honors, however, had, before doing murder, to cut the mistletoe from the sacred grove and then engage in the mortal combat. If the Rex won (as sometimes no doubt he did), it would be interesting to know that he offered up his fallen antagonist to Virbius or Diana.

But we have not here to inquire further into the causes of this extraordinary procedure. We have, instead, to keep attention upon the fact that the King of the Wood forms the connecting link between Diana and Virbius, and then to adduce a circumstance and one or two facts related of Caius Cæsar (Caligula) by Suetonius in his life of that emperor.

It is therein stated that this interesting tyrant, being of a mind that the reigning Rex Nemorensis had enjoyed his sinecure too long, gave permission to one of his stalwart slaves to go and wrest the priesthood from him, if he could. We do not hear the result of the struggle.

The question arises, Why should Caligula have been interested in such a matter, or in the special priesthood of Virbius and Diana?

If we recall the most salient features of the emperor's daily life we shall find that the two passions, *par excellence*, of this maniac great-nephew of Augustus were (1) for horses and (2) for the water. The latter taste he may have acquired through having been brought up at Capri under the Emperor Tiberius, who once prophetically said of him, "I fear I am rearing a watersnake (*natricem*) for the people of Rome."[7] At a later day, as if in imitation of Xerxes building his bridge across the Hellespont, Caligula set about constructing one three and a half miles long, from Baiae, in the sea, even to Puteoli (Pozzuoli).

As to his obsession for the circus, the same writer tells us that he was so extravagantly fond of the charioteers of the Green faction that he supped and lodged constantly in the stables where the horses were kept. He made a present of two million of sesterces to one Cythicus, a driver of chariots. The day before the circus games he used to send soldiers to enjoin silence in the neighborhood, so that his favorite horse "Incitatus" (Go-ahead) might not be disturbed. To honor this favorite animal, besides a marble stall, an ivory manger, purple housings, and a jeweled frontlet, he appointed a mansion, fine furniture and a retinue of slaves, to serve for the reception of such as were invited in the horse's name to sup with him. It was even said that he proposed to make him consul.[8]

One especial circumstance (as we have already noted), which has come down to us respecting the cult of Virbius at Nemi, is that no horse was permitted to enter his consecrated precinct. The Romans attempted to explain this by averring that it was because the horses which drew his chariot had killed Hippolytus, son of Theseus, a favorite of Diana, whom (we have already noted) they had learned to identify with Virbius. Pausanias says that at Epidaurus the Temple of Æsculapius contained a tablet recording that Hippolytus on returning to life had dedicated there to Æsculapius twenty chariot horses. It is difficult to say whether his name, signifying the "horse freer," derives from the story, or the story from it. He was possibly a god of hunting or chariot racing; and in all probability was a male counterpart of Diana. At any rate, the connection of Virbius with Diana and Virbius with unlucky chariot horses was quite sufficiently made out to the Roman mind in imperial times. Mr. Frazer and others infer, with much probability, that an annual horse sacrifice, like that to Mars at Rome, was made to him at Nemi. Here, then, it is of interest to remember that the Aventine temple of Diana overlooked the Circus Maximus.

I venture to suggest, therefore, that this chariot racing may in some way have been the very reason for Caligula's attention having been drawn to the Lake of Nemi and its priest-king. Moreover, that the presence on the spot of a votive vase representing a circus race, and the fragments of male statuettes of charioteers, may be accounted for here by the cult of Virbius, that had been overlaid by the Greek legend of Hippolytus, the favored of Diana. It is manifest that so delirious a devotee of the circus as this emperor had natural reason for holding intimate relations with all divinities connected with the steed, and especially as against evil fortune with it. It was for such a reason, perhaps, that we find him insolently proclaiming his intimacy with Castor and Pollux, the horse-taming sons of Leda and Jove, and exposing himself nude, between their statues in the Forum, in order (it was averred) to obtain a share of their worship. It is manifest that terra cotta statuettes were "votive."

But let us return to Caligula's other passion—that for water, and the things of the water. It was probably on the occasion of his visit to Syracuse, where he exhibited Grecian games, that he first learned about a celebrated galley once made there, by Archimedes, for Hiero to present to Ptolemy, king of Egypt. This amazing vessel obviously amounted to a magnificent floating villa; for besides containing a banqueting hall, a library, a temple, and baths, it was adorned with trees, flowers, and fountains, and a piscina. It thus surpassed in its enchantment the Atlantic triumphs of our own day.

Let us recall what Suetonius says further of this extraordinary emperor: "He built two galleys having ten banks of oars, the poops of which blazed with jewels, while the sails were parti-colored. These were fitted up with ample baths, galleries, and saloons, and supplied with a great variety of vines and growing fruit trees. In one of these he would sail in the daytime along the coast of Campania, feasting amidst dancing and concerts of music. In building his palaces and villas there was nothing he so much desired to effect as what was considered impossible."[9]

Now, if he built such amazing galleys, like that of Hiero, for the coast of Campania—mad as such a feat undoubtedly was—to do the like on a little deeply-shut-in lake, like this of Nemi, was surely even more crazy. But here, precisely at this northern end of the lake, there are lying at this moment, at right angles to one another, two galleys such as Suetonius has described; and although they have been locally known for many centuries as belonging to Tiberius, recent research beneath the water has succeeded in appropriating them to their real constructor. For on several lengths of leaden piping laid for the purpose of supplying water in and about these huge galleys, and which have been brought up by the divers, the inscriptions read: "Gaii Cæsaris Augusti Germanici"; therefore, unquestionably, they pertain to the son of Germanicus, otherwise to Caligula, and so they must be dated between the years A. D. 37 and A. D. 41. These pipes measure 9 inches in diameter (23 centimeters). This date has been further corroborated by the discovery of tiles bearing the name of Marcus Fulvius Zosimus, which occurs in other imperial structures of that period. Further, the exquisitely realistic sculptures in bronze[10] found among the fittings of the sunken ships only serve to amplify the assurance as to the period to which they belong. Among these occurs an arm and hand slightly archaic, having very square finger nails.

This brings us to the story of archæological research relating to the subject, and this (it is well known) commences with the fifteenth century. About the year 1435 Cardinal Prospero Colonna, at that time owner of the castles of Genzano and Nemi, the two villages overlooking the lake from the lofty ridge of its crater, having learned that the fishermen not infrequently drew ashore in their nets objects of wood and bronze which evidently belonged to sunken structures, began to inquire how it could be that such should have been constructed there, in a small inland lake surrounded by really high mountains. His curiosity led him to desire closer acquaintance with the strange but undoubted facts. To this end he communicated with Leon Battista Alberti, the celebrated architect of Rimini Cathedral. The latter entered enthusiastically into the subject, and presently devised some large rafts laid upon quantities of barrels, capable of sustaining cranes and great windlasses with which he presently proposed to raise the imagined vessel. He then procured from Genoa expert divers who should descend for him into the lake to ascertain the proportions, and to attach four-pronged anchors and ropes, so as to draw it to land.

One result of this bold experiment was to break off, in the effort, a portion of the stem of the vessel. The operation caused so great a sensation in Rome that crowds of eager folk, including grand ladies of the Pontifical Court, came out of the city in order to inspect the objects discovered and to carry off mementoes. Among these of course were beautiful marbles, plates of lead, and portions of the pipes before mentioned, together with magnificent bronze nails—some even a cubit in length! Flavio Biondo, a contemporary, in his "Italia Illustrata," relates that

[2] Cf. Mon. Antichi dei Lincei, xiii, p. 58.
[3] Fasti, iii, 271.
[4] C.I.L. x. 1498.
[5] II, 27, Pausanias (J. G. Frazer).
[6] Dion Halic. iv. 39.
[7] Suetonius, Vita Calig. xi.
[8] Suetonius, Vita Calig. iv.
[9] All now placed on view in the Museo Nazionale, at Rome.
[10] Suetonius, Caligula, xxxvii.

the wood of which the vessel was constructed was recognized by Alberti to be larch, or "larice." We today are enabled to corroborate a curious detail—that externally the vessels were coated with lead, covering a stiff lining of woolen-cloth padding fastened in with bronze studs. The wonderment, however, lasted but a little time. The expense prevented further work.

The operations were, in fact, suspended until 1535, or a century later, when another architect and military engineer, Francesco de' Marchi, of Bologna, was called in to try new experiments for raising the obdurate vessel. He tells us:

"I have seen and touched it with my hands, so I will speak something of that which I know. The ship lies sloping in the lake and near to the shore which looks eastward. Master Guglielmo da Lorena made a contrivance by which he entered the water and made himself descend to the bottom of the lake; and there he remained an hour, more or less, just as he wished, until the cold drove him up again. With this contrivance of his, one can work, sawing, cutting, corking-up, tying ropes; one can also operate with hammers, chisels, pincers and other such tools, though one can use but little force because of the hindrance of the water. When the sun is shining one can see not a little, as when I was there on July 15th, 1535. One views (the object) through a crystal window of about the size of one's palm; and everything seen through it, however small, appears large; much larger than it really is. I say that the fishes called 'Laterini' in this lake, which are no bigger than the smallest finger of one's hand, look as fat as a man's arm and as long as three palms. And had I not known about these fishes I should have been much alarmed, owing to their multitudes. For I carried with me four ounces of bread and one ounce of cheese to eat; and the bread being dry it crumbled; wherefore the fishes came around me in vast numbers, and being without my garments they began to prick me. I drove them away with my hands; but they didn't mind that, feeling that they were in their own house, as it were. I caught one, which seemed quite large; but it proved to be no fatter than my second finger. I carried it above with me, thinking it might weigh thirty ounces, but it proved to weigh no more than twelve. The reason I had no garments on was because in the days of my former master, Duke Alessandro de' Medici, one of the fishermen in the Arno went to fish with his hands and dived beneath the river. There he got caught in the branches of a sunken tree and was drowned. This was my reason. Master Guglielmo wished me to stop up my ears with cotton, musk, etc. But this I forbore to do, lest I should not hear if called. And, although I was not deeper below the water than six 'Canne Romane,' and was called at many times at the top of the voice, I failed to hear and yet I heard well enough the sound of two stones when struck together below the water at half-arm's length, and further. I staid half an hour down there the first time."

He goes on to describe how his nose began to bleed and also his mouth and ears, and he had to give a sign to his comrades to draw him up. He presently plunged in, he says, for a swim, and the bleeding ceased. When next he went down he attached ropes to the wreck and enough of it to load two stout mules was drawn up by the windlass working on the raft above. The wood now proved to be of three species, larch, pine, and cypress; while the pegs were of oak. He found many bronze nails as fresh as if made yesterday. These, he says, fastened the plates of lead on the exterior. There was also a lining of linen between the lead and the timber. Within the ship were pavements of tiles two feet square (bipedales), also segments of red marble and enamel.

"Here were the rooms of the palace, which I did not dare to enter, both for fear of losing myself and also on account of the machine within which I was, which if a man did not keep it upright, he would suddenly be drowned by the water coming in; though one who knew how to swim might save himself by quitting the machine. Master Guglielmo said that there were beams of bronze down there; but I did not see them. We found anchors which had been used in operations in the time of Flavio Biondo. Measuring the ship, we found it in length seventy canne,[11] and in width thirty canne, the height from keel to deck eight canne. All my measurements and relics, however, were robbed from me by certain ones who hoped to discover in the material something about the make of this ingenious instrument of Master Guglielmo. But they found nothing; and I have sworn on the Sacrament not to divulge the secret while the Master lives. All I know is that this ship is in this lake, and only one particle is wanting to its completeness, and that is wanting because Master Guglielmo took it away."

Various attempts were made once more, in 1827, by one Annesio Fusconi, an engineer, who used Halley's diving-bell; but the results were unsatisfactory. Nibby, the Roman archaeologist, was present, and came to the erroneous conclusion, with those who were employed in diving to see the remains, that they must have pertained to a villa which Julius Cæsar is known to have built at Nemi, but which, displeasing him, he destroyed. "He pulled down a villa which he had built from the foundations at Nemi, because it did not exactly suit his taste, although his means were, at the time, but slender."[12]

The real secret of the waters of Nemi, so long and jealously preserved, remained with them until September, 1895, when Signor Eliseo Borghi obtained permission from Prince Orsini to employ divers and make fresh research. Guided by the fisherman, Cav. Vittorio Malfatti and two divers soon located the first of two magnificent galleys that lie therein, at a distance sixty-five feet from the shore. It lies at a depth of thirty feet. At right angles to it, some two hundred feet distant, they found a second ship; and besides these there was found a structure resembling a pier.

By attaching long cords with corks to the galleys, the divers gradually sketched out in outlines on the surface the shape of the vessels. The writer can recollect the feeling of awe which thrilled those looking on at the design developing slowly upon the face of the waters, informing us of the peculiar, if not unique, historic wonders below. The length of the first vessel was found to be ninety feet, by twenty-six in the beam. The decks were found to be paved with elaborate mosaic work in porphyry, green serpentine, and *rosso antico*, intermingled with richly-colored enamel. The bulwarks are cast in solid bronze once gilded, as traces showed.

From other parts of this vessel nearest the shore, which lies in shallower water than its fellow, the divers brought up the various beautiful sculptures besides quantities of fragments confirmatory to the letter of De' Marchi's description as to the structure and ingenious means employed to keep out leaks. The outer edge of the vessel is covered with cloth smeared with pitch, and over this occur folds of thin sheet-lead doubled over and fastened down upon it with copper nails. It may be verified, when a yet more determined attempt shall be carried out to make the lake yield up bodily its treasure, that these great galleys may have been designed by their megalomaniac builder, Caligula, in imitation of those described in Suetonius as having been used by him along the neighboring Campanian coast, for floating villas; but as to their purpose, it is at least as probable they were connected with the cult and festival of Virbius, representative of Hippolytus, the charioteer, as with those of Diana; were it not that the ancients, as well as some moderns, have held that there is immediate relationship between the Moon-Goddess and the lunatic. It may thus have been that the Flamen Virbialis had advised the emperor upon the spot that the "Rex Nemorensis" had enjoyed too long a reign, or had in some way proved tyrannical. This would account for the flippant order of the emperor that one of his slaves should challenge him, in order to assassinate him and appropriate his office.

The day when these galleys of Caligula shall be brought to land will be veritably a red-letter day in the archæological calendar; but, owing both to their condition and the depth at which they lie, we may well doubt if that can ever take place.

[11] A canna = 6 feet 5 inches.

THE LARGEST COLUMN IN THE WORLD.

THE following account of the largest column in the world is taken from the Boston Mechanic, published in 1835. It was erected by Nicholas, Emperor of Russia, to the memory of his brother, the late Emperor Alexander.

The shaft was placed on its pedestal on St. Alexander Nefsky's day (August 30th, old style, 1832), in presence of the imperial family, nobility, citizens, and strangers. The day was remarkably fine, and an immense concourse—an almost countless multitude—assembled to witness the operation, in the large square in front of the Hermitage, or winter palace of the emperor.

The monument is of red granite, or rather sienite. The pedestal, which is square, is forty feet high; the shaft is round and in one piece, and is eighty-five feet high, and twelve feet in diameter at the top. It weighs six hundred tons and supports a colossal bronze statue, representing an angel holding a cross.

The statue, with its pedestal, including the capital of the column, is thirty-five feet high; and the height of the monument, from the ground to the top of the statue, is one hundred and sixty-five feet. The stone was brought from Finland, and transported to St. Petersburg in a ship built for the purpose, towed by a steamboat.

The inclined plane on which the shaft was rolled from the river Neva to its present site, contained a forest of wood, and cost in that country, where it is so cheap, a million of rubles, or $770,000. The column was raised and safely placed on its pedestal by means of sixty capstans, manned by 2,500 veterans, who had served with Alexander in his most glorious campaigns. Each of them wore badges of honor.

The preparations for the stupendous undertaking were so complete that not the slightest accident occurred; and during the operation of raising the shaft, not a whisper or a word was heard throughout the vast multitude who witnessed it; the most profound silence prevailed, and one of our friends, describing his own sensations, says he "felt as if it were criminal to draw a breath."

[12] Suetonius, Julius Cæsar, xlvi.

ARE THE SENSES EVER VICARIOUS?

By JOHN G. MCKENDRICK.

IT is a prevalent opinion that if a human being is bereft of one sense, one or more of the other senses become more acute, and thus establish a compensation. For example, it is generally believed that the blind have the senses of touch and of hearing, more especially of touch, developed to a degree of acuteness not found in those who see, and that, in this way, the blind find their way about the world with an accuracy that is often surprising. The blind have even been credited with the ability to discriminate colors by the sense of touch, and some have attempted to support this supposition by an appeal to the sense of heat or cold possibly, for physical reasons, associated with a particular color. A compensating arrangement has also been attributed to the deaf, and more especially to the deaf-blind. Such notions, however, must be abandoned before the evidence of recent investigations.

The question is discussed with much shrewdness in a paper on the physiology of the blind, by M. Kunz, director of the Institution for the Blind at Illzach-Mülhausen. He refers especially to the observations of Prof. Griesbach, made on a considerable number of blind persons in the Mülhausen Institution, and also, for the sake of comparison, on pupils in the public schools of Mülhausen of the same age. The results are somewhat surprising. As regards perception of the direction of sound, there is no difference between the seeing and the blind. The average distance at which sounds could be heard was essentially the same in both classes. As tested by Zwaardemaker's olfactometer, the delicacy of the sense of smell was rather in favor of the seeing. Griesbach used his own æsthesiometer, with parallel pins on springs, instead of the old Weberian method with compasses, in testing the acuteness of touch, with the result that the average minimum distance, say on the tip of the forefinger, etc., at which two points were felt was greater in the blind than in the seeing; in other words, that the seeing had a finer sense of touch than the blind. It is generally supposed that the palp of the forefinger of the right hand, which is used by the blind in feeling the points in Braille's system of teaching the blind to read, must be very sensitive, but this was found not to be the case. Too high a degree of sensitiveness to touch is rather unfavorable to discriminating the points in Braille's type, and it is curious that when, in the blind, the epidermis of the skin covering the right forefinger becomes thickened by manual labor or by laborious practice in "reading," the discrimination of the points becomes easier. It was observed, also, that sometimes in the blind there was a difference between the two forefingers.

There appears to be no evidence, therefore, that blindness, *per se*, increases the sensitiveness of the other senses, but, on the principle that if one sense is defective the others are likely to be also defective, the other senses, in the average blind, are less acute than in the seeing. How, then, are we to explain the wonderful way in which the blind avoid obstacles and find their way about? It has been supposed that by practice the skin of the face, in particular, becomes more sensitive, or, in other words, that the blind habitually pay attention to currents of air playing on their faces, and especially they may be influenced by sensations of temperature. They say that they "know" they are near a wall because they "feel" it, although they do not touch it. It would be interesting to examine the blind as regards the sensitiveness of the hot and cold spots of the skin revealed by Goldscheider and others. The theory of sensitiveness to the direction and temperature of air currents is supported by the observation that the blind do not so readily avoid an obstacle if the face is covered or even if they are blindfolded. This suggests the question: Are all so-called blind people absolutely insensitive to light?

It is also believed that the blind pay an almost involuntary attention to the direction and quality of sounds. The blind man "taps" his stick. When snow is on the ground the blind have difficulty in avoiding obstacles. One must not forget, however, the physical element that enters into the question. The effort of attention is super-added to the sensory impression. Impressions may reach the sensorium of which we are usually unconscious, but they may be detected by an effort of attention. This was strongly pointed out by Helmholtz. The senses of the blind are not more acute than those of normal people, but the necessities of the case oblige the blind to pay attention to them.—Nature.

SUB-AQUEOUS PHOTOGRAPHY.—I.*

PHOTOGRAPHING AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT.

BY JACOB REIGHARD, PROFESSOR OF ZOOLOGY, UNIVERSITY OF MICHIGAN.

MANY things have contributed in recent years to extend the use of photography into fields of natural history not previously occupied by it. Dry plates and films have been made more rapid and, with the advent of the non-halation and orthochromatic sorts, have been adapted to every use; with new sorts of optical glass it has been possible to construct photographic lenses of great speed; cameras and accessories have been made portable and suited to a variety of needs. As a result we find in scientific publications, as well as in more popular books and periodicals, excellent photographs of living animals and plants in their

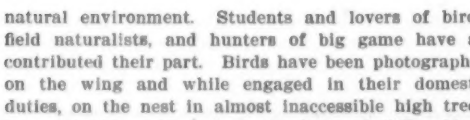


Fig. 1.—Diagram Illustrating the Photography of Objects Beneath the Water by a Camera Above the Surface.

natural environment. Students and lovers of birds, field naturalists, and hunters of big game have all contributed their part. Birds have been photographed on the wing and while engaged in their domestic duties, on the nest in almost inaccessible high trees, on mountain crags, and on the faces of cliffs. Mammals have been photographed in nature under a great variety of conditions. Reptiles, amphibians, insects—every variety of terrestrial animals has been pictured by the lens.

Quite in contrast has been the limited use of photography for aquatic organisms. Shufeldt (1898), Dugmore (Jordan & Evermann, 1902), Saville-Kent (1893), Fabre-Domergue (1898), have from time to time succeeded in making excellent photographs of animals in aquaria under more or less artificial conditions, but the work has been carried scarcely beyond this (see Boutan, 1893, 1898, 1898a, 1900, and Raudaux, 1908). The present paper deals rather with the photography of aquatic organisms, not merely in their native element, but in their native environment and under normal conditions. It attempts to show how they may be photographed, not by taking them from their native haunts and placing them in artificial containers, but by carrying the camera into the field. The methods described make it possible to do in some measure for aquatic animals what has been done for birds and other terrestrial forms.

* A reprint of a Bulletin published by the Bureau of Fisheries.

PRINCIPLES OF PHOTOGRAPHY OF SUBMERGED OBJECTS.

In air the naturalist can by one method or another photograph what he sees. When he looks into clear water he may see much that it seems possible to photograph. If the surface is disturbed objects beneath it appear distorted and wavering, but if the surface is smooth they may appear as sharp and steady as though viewed through air alone. In the latter case the photographer may set up his camera and find that he can get a perfect image on the ground glass; but if he then exposes a plate with the expectation of getting a good negative he will be sorely disappointed. Only rarely does he get any image at all of what lies beneath the water's surface. Usually the negative shows only the surface itself, and that appears as opaque as though the camera had been pointed into a lake of tar. The writer has often attempted such photographs, to find on his negative no visible impression of the fish which showed so clear on his ground glass. This is doubtless a common experience. Why is it?

Explanation will be clearer by referring to the diagrammatic Fig. 1, where the camera (c) is pointed toward a fish (x-y) beneath the surface (a-b) of the water. The fish is illuminated chiefly by rays of light which enter the water almost vertically. The rays of light $x\,x'$, $y\,y'$, reflected from the fish, which strike the surface of the water from below at an angle less than 48 deg. 35 min. with the vertical, emerge into the air, while at the same time they are bent from their course, as shown in the figure. Some of these rays converge to the lens, and thence diverge to form on the ground glass the image $i\,i'$. When the photographic plate is exposed these rays, with the rays from other submerged objects, form an image on it, as they do on the ground glass. Yet this image does not appear in the negative, for if the surface of the water is smooth it acts as a single great mirror which, although it permits a part of the light to penetrate, yet reflects another part, greater the more obliquely the light strikes the surface. For this reason the images of sky and trees and other distant objects are often seen mirrored on the surface of smooth water. Some of these reflected rays ($z\,z'$, $w\,w'$), after leaving the surface of the water, enter the lens of the camera and form an image. The fish is a near object and if the camera is focused upon it the image of the fish is sharp on the photographic plate. The reflected rays from the water's surface come usually from distant objects, commonly sky or clouds. When the camera is focused on the fish a sharp image of these distant objects is formed, not on the photographic plate, but in a plane situated somewhere between that plate and the lens, as at $I\,I'$. After forming the image $I\,I'$ these rays again diverge and strike the photographic plate. The plate is thus flooded by light from distant objects that are wholly out of focus, so that such rays do not form a distinct image on it. This reflected light is usually brighter than the light which forms the image of the fish. It affects the plate with greater intensity, so that when the plate is developed the image of the fish is quite obscured by the general fog produced by the brighter light. There appears in the negative only a uniform dark haze, which represents the surface of the water.

If the ground glass is put in place and brought by focusing into the plane $I\,I'$, then the sharp image of distant clouds and trees is seen on it, while the image of the fish lies behind the ground glass and is no longer clearly visible. If the water is smooth, a plate exposed under these circumstances gives a sharp nega-

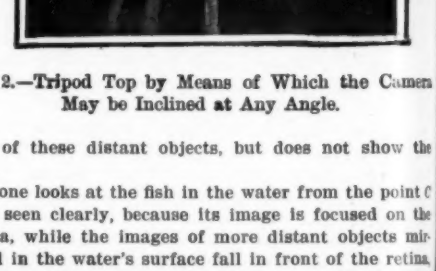


Fig. 2.—Tripod Top by Means of Which the Camera May be Inclined at Any Angle.

tive of these distant objects, but does not show the fish.

If one looks at the fish in the water from the point c it is seen clearly, because its image is focused on the retina, while the images of more distant objects mirrored in the water's surface fall in front of the retina, and the objects from which they come are therefore not seen. The observer neglects the glare of light from these distant objects, fixes his attention on the fish, and sees it. If now, while still looking toward the fish, he adjusts his eye to distant objects by relaxing the ciliary muscle, these are clearly seen mirrored in the surface of the water, while the fish is no longer sharply seen. Similarly, if a mirror is laid on the ground so as to reflect the clouds and its image is examined by focusing in a camera, it is impossible to get at the same time on the ground glass a sharp image of the clouds reflected in the mirror and of the frame of the mirror or other near object. It is only when the mirrored object lies near the surface of the water that its image can be focused on the photographic plate or retina at the same time with that of a submerged object near the surface. It nearly always happens that the light entering the camera from distant objects mirrored in the surface of the water is so much more intense than that from submerged objects that the images of the latter are quite obliterated on the photographic plate. Sometimes, on the other hand, when the camera is pointed nearly vertically into the water at an object over a light-

Fig. 6.—Photograph of the Nest of a Small-mouthed Black Bass (Micropterus Dolomieu) Taken with the Aid of a Screen, the Camera Above the Water.

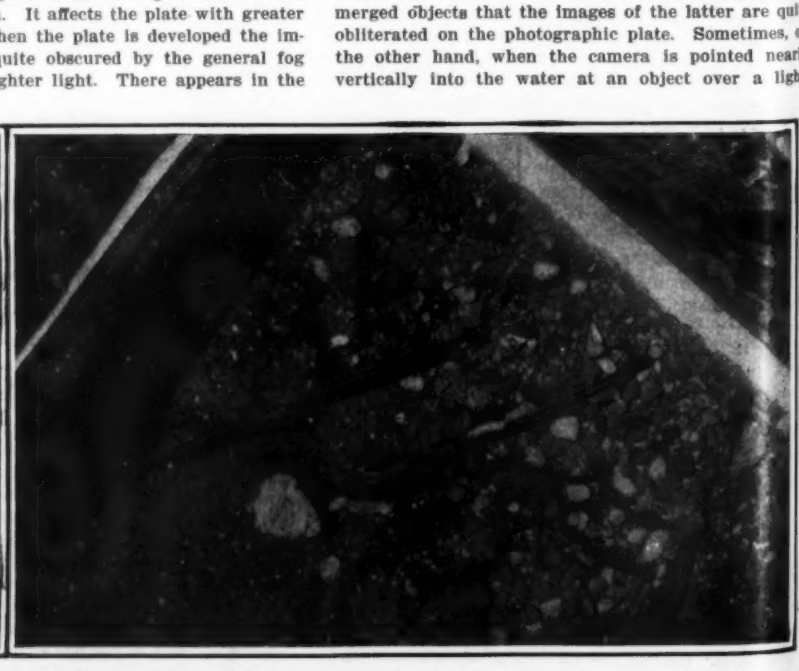


Fig. 6.—Brook Lampreys (Lampetra Wilderi) on the Nest, Photographed Through the Water Glass Shown in Fig. 4 in About 8 Inches of Running Water.

colored bottom, the emerging light is more intense than the reflected light, and there is obtained a more or less fogged negative which shows submerged objects. This is the more apt to be the case if the photographer has the sun at his back. (See Saville-Kent, 1893.) At other times, within the limits of the reflected image (not the shadow) of a dark-colored bridge or building or dense foliage, one may obtain a fogged negative, showing submerged objects. In this case also the partial success is due to the fact that the reflected light is less intense than that which comes from the submerged objects to be photographed. It is not often, however, that the submerged objects that one wishes to photograph are found within the reflected images of dark-colored backgrounds of sufficient size and far enough away.

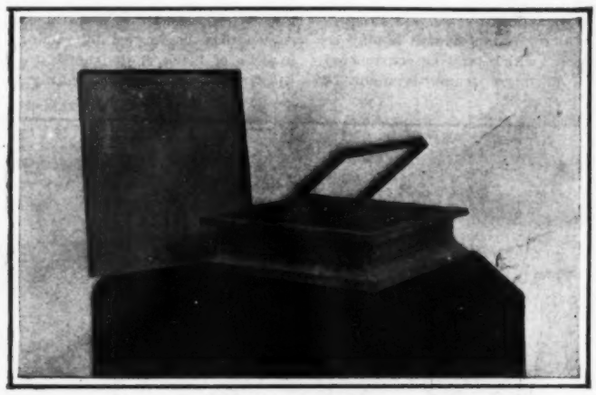


Fig. 4.—Water Glass Designed by the Writer to be Used for Observation or Photography of Objects Under Water. The cover is shown at the left.

The above discussion is based on the assumption that the surface of the water is smooth so that it acts as a single mirror. If the water surface is disturbed it is broken into numerous smaller surfaces, concave, convex, or plane, and each of these acts as an independent small mirror. These form distorted images of portions of distant objects, of natural size, magnified or reduced; and the light from them entering the camera affects the photographic plate in such a way as to obliterate the dimmer image of any object lying beneath the water. At the same time the light from the submerged object is refracted in various directions as it emerges into the air through the irregular surface of the water, so that its image as formed on the retina or ground glass is neither sharp nor steady.

From the foregoing discussion it appears that attempts to photograph submerged objects with a camera placed in air can result in only partial success, and this but rarely. Failure is due to the fact that the photograph is made through the surface of contact of two media, water and air, of very different refractive powers. If this surface is not perfectly smooth the light from an object beneath it is, upon emergence, refracted unequally at different parts of the surface and can not form a clear image on the ground glass. Whether the water is smooth or rough, its surface reflects a part of the light which strikes it, and thus acts as a mirror. This reflected light makes it impossible, except under unusual conditions, to obtain photographs of submerged objects. To obtain such photographs the surface of the water must be smooth and light reflected from it must not enter the camera. Two modes of procedure suggest themselves:

(1) The camera may remain above the surface of the water. In that case the surface of disturbed water must be rendered smooth and the light from objects above water must be prevented from striking its surface at such angles as to enter the camera in sufficient amount to fog the plate. Methods devised by the writer for accomplishing these two results are taken up and illustrated in the following section.

(2) The camera may be placed beneath the surface of the water, so that this surface does not intervene between the camera and the object to be photographed. The light which enters the camera is therefore neither refracted nor reflected at this surface, and images may be obtained on the ground glass as clear and steady as though viewed through air alone. Methods of the writer and others for accomplishing this are described and illustrated in the final section of this paper.

A NEW METHOD OF PHOTOGRAPHING SUBMERGED OBJECTS WITH THE CAMERA ABOVE THE SURFACE.

It was pointed out in the preceding section that if the camera with which submerged objects are to be photographed is to remain above the surface of the water means must be found (1) greatly to reduce the amount of reflected light entering the camera from the surface of the water, and (2) to render the surface of the water smooth. We may consider first the case in which the surface of the water is smooth, so that it is necessary merely to minimize surface reflection.

The method to be described is best adapted to objects in water not more than 2 or 3 feet deep, and the best results are obtained when the water is less than a foot in depth. Any type of camera may be used, but since the objects to be photographed are necessarily quite near the camera they are out of focus with a fixed-focus camera, so that the best results are obtained when the camera is one that can be focused. Since the objects to be photographed are usually in motion, and since the surface of the water may at any time be roughened by a puff of wind, it is best to use a lens suitable for instantaneous exposure—a lens of a speed not less than f 8. The operator should first select the point from which the picture is to be taken. He should, of course, have the sun at his back or to one side. If possible he should stand on the bank or on some fixed support which extends above the surface of the water. From such a position the camera is at a greater height and may usually be directed at the surface of the water at an angle of about 45 deg. or less from a vertical extending upward from this surface. Rays of light from submerged objects striking the surface of the water from below at an angle of 48 deg. 35 min. from a vertical drawn downward (or at a less angle), emerge. They may thus, after refraction, reach the camera as indicated by the line $x\ x'\ i'$ in Fig. 1. Rays which strike the surface of the water from below at an angle of more than 48 deg. 35 min. with the vertical are, on the other hand, reflected at the surface so that they do not emerge and enter the camera but pass down again into the water, as indicated by the line $x\ m\ n$ in Fig. 1.

If the operator is unable to find a fixed emergent support for the camera he may make the exposure while standing in the water. The camera may then be held in the hand or may be supported on a tripod which rests on the bottom. As the legs of the tripod are likely to sink into the bottom they should be extended to their full length. Where the bottom is firm an elevated position may be obtained for the camera by using a tripod with legs some 10 feet long, such as dealers sell for use in making pictures of large groups. In such tripods one leg forms a ladder by which the camera may be reached.

The tripod top should consist of two rectangular wooden pieces, as shown in Fig. 2 and in section in Fig. 1. To the lower piece, which has a large circular opening at its center, the legs are attached. The camera is fastened by the tripod screw to the upper piece in such a way that one of the legs projects directly backward instead of directly forward, as is usual. The two pieces are hinged together at one edge, so that they may lie parallel to one another or may be separated like the covers of a book until the upper piece forms an angle of 90 deg. with the lower. A rod is pivoted by one end to the upper piece at the middle of its free edge, so that it swings freely in the vertical plane. This rod passes through a perforated metal block pivoted by one end at the middle of the free edge of the lower piece so as to swing freely in a plane vertical to that piece. When the two pieces are separated by moving the upper one on the hinge which connects them the rod slips through the opening in the block and may be firmly clamped at any point in its length by means of a set screw. Thus the upper piece may be held firmly at any angle to the lower piece from 0 deg. to 90 deg., and the camera may be pointed at the water at any desired angle. The position in which the legs of the tripod are attached permits the camera to be pointed directly downward in the space between the two front legs, whereas if the legs were attached in the usual manner with one leg in front it would be impossible to bring the camera into the vertical position. Tripods of this type are to be found in the market or may be made from an ordinary tripod by any mechanic.

When the operator has placed his camera and roughly adjusted it, he should set up a screen to cut off the light reflected from the surface of the water into the camera. Any piece of dark fabric, a blanket, shawl, or for small objects even a coat, may be used. It may be supported by hand or tied to poles stuck in the bottom. The writer carries into the field a screen made by sewing together pieces of black calico to form a sheet either 6 or 9 feet square. To three of the edges of this, at intervals of about a foot, are sewn pieces of tape each about a foot long and attached at its middle so as to leave 6 inches projecting on each side. One piece of tape should be attached to each corner of the screen. Two poles are cut of sufficient length to project 6 to 10 feet above the water when firmly set in the bottom. The poles are sharpened at one end, and beginning at the unsharpened end the square of calico is tied to them by the opposite edges by means of the tapes. The third side to which tapes are attached is the upper, between the unsharpened ends of the poles. The poles are now thrust into the bottom on that side of the camera opposite the object to be photographed and so that they slant toward the camera. The screen ($s\ s'$, Fig. 1) is thus stretched upward from the surface of the water in a slanting position, so that its upper edge is nearer the camera than its lower. If the two poles are pulled together by the weight of the cloth or the action of the wind so that the screen sags, a third pole tied between their upper ends will keep them apart, while the tapes on the upper edge of the screen will serve to attach it to the cross-pole.

If the operator now returns to the camera he will see the screen mirrored in the surface of the water. The object to be photographed should fall within the limits of this mirrored image as seen from the camera.* If it does not, the screen or the camera must be shifted until it does. The operator will see also the shadow of the screen. This should not fall on the object to be photographed. The screen should, if possible, be adjusted by slanting it or by moving one of the poles so that the sun strikes it nearly edgewise, but yet does not strike that face of it which is toward the camera. If this adjustment is properly made the shadow of the screen is a very narrow band, which lies beneath the screen and a little nearer the camera than its lower edge. The full sunlight then falls on the object while the rays from distant objects which would otherwise be reflected into the camera from the surface of the water are cut off. If the sunlight

Fig. 5.—Two-foot Water Glass Supported on Four Legs and Provided with Screen, as Used for Studying and Photographing Lampreys (Lampetra Wilderi).

* Saville-Kent (1893) apparently utilized this principle when photographing with a vertical camera on the Australian barrier reefs, but Rudaux (1908) stated the principle explicitly as applied in photographing in natural waters with a vertical camera objects within the reflected image of the tripod top. Neither recognized the broad application of the principle here described.

is permitted to fall on that face of the screen which is toward the camera, it is reflected from the screen to the surface of the water and thence into the camera. A picture taken under these conditions may show, besides the object under the water, also the screen itself, although this image of the screen is usually so faint that it does not interfere with the use of the picture for scientific purposes.

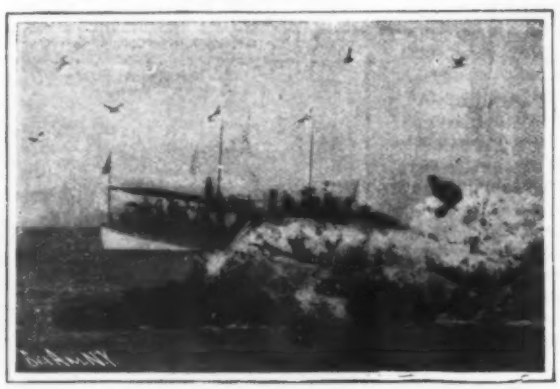
When the screen has been properly set the operator has merely to adjust the camera and make the exposure in the customary way. If the subjects are fish they will usually have been frightened away, but if fish are engaged in nest building or in some other occupation that attracts them to a particular spot, they will, in most cases, return after a time varying from five minutes to an hour. The operator has merely to remain quiet until this happens. The photographer may focus his camera on the spot to which the fish is likely to return and then withdraw and operate the camera from a distance by pulling a string or pressing a bulb when the fish return. The method is of most use in securing photographs of the nests and habitats of fish in shallow water, yet the writer has succeeded by means of it in making some satisfactory photographs of fish on the nest.

The result of using the screen is shown in Fig. 3, which is a photograph of the nest of a small-mouthed black bass. The screen in this case was stretched on a frame and was held by hand. Within the limits of the reflection of the screen in the water's surface the bottom may be seen clearly. At the center are the larger stones which form the bottom of the nest, and these show sharply the details of their markings. Outside the limits of the reflection of the screen the bottom is not clearly visible; its image has been obscured on the sensitive plate by the bright light reflected from the surface of the water. The sun struck the back of the screen from the left, as is shown by the shadow which lies close to the screen. Within the limits of this shadow the plate was underexposed and details of the bottom are not visible. With a longer exposure as good a negative could have been made of what lay in the shadow.

If the surface of the water is not smooth it may be made so by a water glass, which may be constructed as follows (Fig. 4): A square frame is made of heavy galvanized iron, and measures 3½ inches deep and 12 inches on each side within. One of its edges (the top) is turned outward three-fourths of an inch and then downward one-half inch to form a lip. This stiffens the frame and tends to prevent water from slopping into it. The lower edge of the frame is turned outward about half an inch to form a flat surface, against which the glass, 13 inches square, is bedded in aquarium cement. After the glass is in position four trough-shaped pieces are soldered to the sides of the frame and to one another in the manner shown in the figure. The free edges of these pieces project inward beneath the lower surface of the glass and support it. Before the pieces are soldered into place cement is placed between them and the lower face of the glass. The whole border of the glass is thus bedded in cement on both surfaces and at the edge. To protect the glass when not in use a flat cover is provided, which fits against its lower face. Such a water glass may be floated over the object to be photographed and a screen set up independently of it, or the screen may be attached to the glass itself. For the latter purpose a piece of half-inch band iron may be bent to form the three sides of a rectangle, 8 by 12 inches, and this may be riveted as a bail (Fig. 4) to the inside of the frame, about 8 inches from one side. The bail should turn on the rivets so that it may be depressed into the frame when not in use. A screen may be formed by raising the bail and tying a piece of black cloth from it to the opposite side of the frame. In shallow, running water it is desirable to support the water glass from the bottom in order that it may not sink so much as to displace or distort the object to be photographed. It may be supported on four iron rods which run through metal sleeves soldered to the four corners of the frame. The rods may be fixed in any position in the sleeves by means of set screws, and may project upward far enough to support the upper edge of the screen. A water glass arranged in this way is shown in Fig. 5, where it is being used for observation, but with the same glass photographs were obtained of lamprey eels in the act of spawning. Such a photograph is reproduced in Fig. 6, where the rough surface of the running water made the use of the water glass imperative. The white bands across the picture are the edges of the frame of the water glass. Outside this

A Large Jelly Fish. Specimens as Long as 30 Feet Have Been Seen.

The Giant Spider Crab Dining.



Glass-Bottomed Boat Off Sea Lion Rocks.

Spotted Rock Fish (Sebastodes vexillaris).

In the Hanging Gardens. A Perfect Scene in the Kelp Beds of Santa Catalina, Under Water.

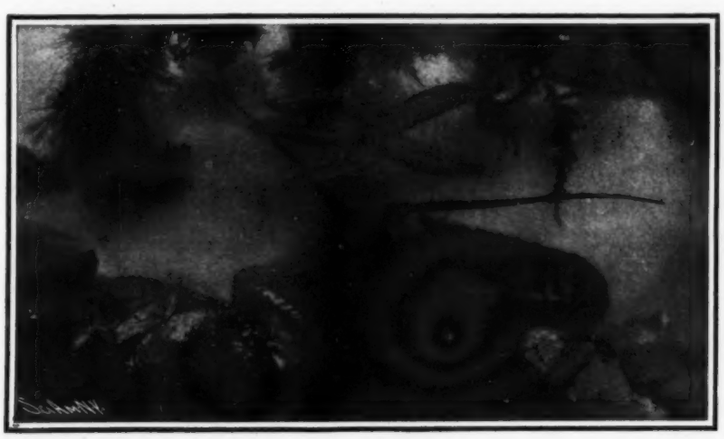
Photographs taken through a glass-bottom boat at Avalon, Cal.

frame at the right, where the water is rough, little is visible. The screen was almost as necessary as the water glass.

The writer has used water glasses of this type varying in size from 1 to 3 feet square. Those of 1 foot square are of use chiefly for observation, and even for this purpose the screen is a valuable addition. Those of 3 feet square are so unwieldy that a vehicle of some sort is needed to carry them. The size most suitable for field photography is 2 feet square, since this may be transported by hand.

The method described in this section is suited only to shallow water, where the camera may be supported from a firm substratum. In deeper water the unsteadiness of the boat would interfere with the manipulation of a water glass or a screen. It might be possible, however, to construct a boat of which the water glass and the screen should form constituent parts. The method described permits only of views at angles of from about 48 deg. to 90 deg. to the water's surface. Since it is not practicable to place the camera far above the water at these angles or to use screens of very large size, the pictures that may be taken are of near objects and the field covered by them is of limited extent. If a water glass is used, the camera must be near it and the field is limited by its frame. The method is, however, the only one known to the writer for certain kinds of work. Often, as in the case of the bass nest shown in Fig. 3, the objects to be photographed are in water so shallow that the camera must be placed above its surface; there is not room for it beneath. Often, though the object may be in deeper water, it is so surrounded by vegetation that it can not be seen from a little distance except from above. It must then be photographed from above. Where the water is both shallow and disturbed, as in small streams, the use of a water glass is essential. There are therefore many objects about the borders of lakes and in streams to which this method may be applied when no other known method is available. On the other hand, wherever it is possible to use a submerged camera, results may be obtained with greater ease and certainty in the manner shown in the section which follows.*

(To be continued.)



California Crawfish (Palinurus interruptus). Photographed through an Avalon glass-bottomed boat.

THE PAINTING OF STEEL.

IN the course of an exhaustive paper on "Paint and its Application to Structural Steel," recently read before the Paint and Varnish Society, Mr. Gaston Despierres gave some valuable information on a subject which is from day to day growing in importance. The enormous increase of late in the use of steel in buildings and engineering constructions, he said, "demands increased vigilance and attention to its maintenance and present condition wherever it has been placed, as, either from corrosion, fatigue, vibration, or general deterioration, the metal may become so impaired as to be unfit to do that for which it was designed; and unless it is properly protected by coatings of paint at various periods, those intrusted with its care will assume the enormous responsibility for further catastrophes entailing great expense, and worse still, shocking loss of life. . . .

"The first, or priming coat, upon a surface of steel in a fit condition to receive paint, is of the greatest importance, in view of the circumstances that the union of the paint and the substratum depends entirely upon the adhesion of this coating, and the first problem to be solved in the painting of steel is necessarily—not which paint sticks best on another coat of paint, but which paint adheres most firmly to iron. . . .

"For a long period, red lead alone was employed for this purpose, and even now still enjoys a reputation not altogether undeserved, and, when in competent hands, has given very fair results. However, personally, I do not admit that red lead is the best and ideal pigment for priming, as it must be borne in mind that of all pigments it requires the smallest proportion of oil or varnish in order to form a distributable and well-covering paint; and it must be noted that the protection afforded by the pigment is largely dependent upon the property it has of absorbing and retaining oil.

"Also, on account of its great specific gravity—9.19—the proper mechanical mixture of red lead with oil is almost impossible, as settling and setting take place very rapidly; hence the general practice of mixing in the kettle before the application.

"After many experiments spread over years, I have

The California Sheepshead. Photographed through an Avalon glass bottomed boat.

come to the conclusion that the most perfect priming coat is obtained by the use of orange lead, a pigment of lower specific gravity—6.85—and of finer texture, which, when mixed in certain proportions with an inert pigment having a great oil-absorption, produces a paint which can be properly ground and mixed for use, having, by reason of its fineness, great adhesive power, and being capable, owing to the presence of the inert pigment, of lessening the oxidizing action going on between the oil and the lead oxide, thus shortening the life of the linoxyn formed. . . .

"It is known that the durability of any oil paint depends largely upon the number of particles of pigment, the better protection to the binder and to the metal underneath—the evil of thinning paints too much is therefore obvious. A layer of air exists on all surfaces—hence the importance of rubbing out the paint thoroughly, as otherwise, bubbles of air may be discovered which, coming through the paint, render the coating porous.

"As to the spraying of paint upon structural steel by means of air compressors, I am of opinion that it conveys air and moisture to the metal, and helps the formation of rust; besides, its many disadvantages have led to its abandonment by nearly everyone who has tried it.

"The adherence of paint would no doubt greatly increase if it were possible to heat the surface by artificial heat; but when painting is done on the job, it is impracticable to warm and dry the metal artificially; however, it is a good plan to apply the paint heated to a temperature of 100 to 120 deg. F., especially when the temperature of the air is below 55 deg. This is easily attained by placing the cans of paint in pails of hot water.

"It is important always to note the atmospheric conditions when painting is being done—a temperature of 70 deg. F., and an atmosphere free from moisture, favor the right kind of drying; in fact the humidity is more harmful than a low temperature. Nothing retards drying more than dampness and darkness.

"To aid in the inspection of new work, a shop-coating of linseed oil is often specified. This does, in a measure, protect the iron from rust; but a very uneven film of dried oil is often obtained by this method of treatment. Oil applied to a vertical surface runs off until the layer reaches a certain thickness. When the current meets with an obstruction, it piles up into a thick and uneven coating. The thick parts of the layer may require months to harden into a substance firm enough to be fit to paint over."—Journal of the Society of Arts.

The Glass-Bottomed Boat of Avalon, Cal.

* Following a suggestion first made, we believe, by Prof. Charles F. Holder, of Pasadena, Cal., the water glass has been elaborated into a glass-bottomed boat, which virtually has several large plate glass windows through which the passengers may look down into the kelp forests and view a panorama of the sea. These glass-bottomed boats range in size from rowboats in which a dozen people can be taken out, to side-wheel steamers, so arranged that they can float over the forest and view its wonders up and down the coast. One of these odd craft is so large that several hundred passengers can look down through its windows at one time. Avalon, Cal., is the headquarters for the glass-bottom-boat men, and their vessels cruise up and down the smooth north coast of Santa Catalina, that appears to be admirably adapted for the purpose, being in the lee and abounding in coves and bays—the mouths of cañons that nearly always are smooth and often like disks of steel.

What the voyager in the glass-bottom boat generally sees, and with the same surroundings, is shown in the accompanying illustrations of animals, taken from the kelp forests of Avalon and adjoining waters under the direction of Prof. Charles Holder; in other words, each photograph shows the animal as it has been seen; and as the various forms have never before been photographed and some have never figured in books, they have an especial interest as a contribution to popular entertainment and exact zoological knowledge, and are accordingly here reproduced from the SCIENTIFIC AMERICAN of January 30th, 1904, and June 2d, 1906, as an addition to Prof. Reighard's excellent monograph.—EDITOR.

ENGINEERING NOTES.

Consul A. G. Seyfert of Owen Sound, Ontario, furnishes the following statistics concerning cement in Canada: One-half of all the cement manufactured in Canada is manufactured in the locality of Owen Sound, the daily output here being 3,000 barrels. The demand for concrete material for building the transcontinental railroad has increased the output to the full capacity of the plants during the past year. During 1907 Canada produced 2,500,000 barrels of Portland cement, and imported 1,000,000 more, nearly all from the United States.

The quantity of coal consumed in the manufacture of coke in 1907 was 61,946,109 short tons, valued at $72,784,851. The value of the coke produced from this coal was $111,539,126, a difference of $38,754,275, which represents the profits on the coking operations less the cost of manufacturing and the expenses of administration and selling. In 1906 the value of the coal used was $62,232,524, and the value of the coke produced was $91,608,034, a difference to cover all expenses of manufacture, administration, and profits of $29,375,510.

It is estimated that 150,000 acres are required each year to grow timber for the anthracite coal mines alone. The average life of an untreated mine prop is not more than three years. By proper preservative treatment it can be prolonged by many times this figure. Telephone and telegraph poles, which in ten or twelve years, or even less, decay so badly at the ground line that they have to be removed, can, by a simple treatment of their butts, be made to last twenty or twenty-five years. Sap shingles, which are almost valueless in their natural state, can easily be treated and made to outlast even painted shingles of the most decay-resistant woods. Thousands of dollars are lost every year by the so-called "bluing" of freshly sawed sapwood lumber. This can be prevented by proper treatment, and at a cost so small as to put it within the reach of the smallest operator.

As far as pumping water is concerned, a centrifugal pump can take its suction from almost a perfect vacuum, but since it is a complete failure as an air pump, a very small quantity of air in the suction under these conditions will cause it to cease pumping completely. Since the volume occupied by any given quantity of air increases with the vacuum and the leakage also similarly increases, the probability that air in the suction will cause trouble increases about as the square of the suction lift. If in addition to a high lift, the suction pipe is long and perhaps old, trouble can be predicted to a certainty. In view of these conditions, a 20-foot suction lift, including friction, should be about the maximum. With special design and care 25 feet might be attempted, but only after a thorough consideration of all the conditions.—Power and the Engineer.

The propulsion of ships by gas engines is attracting a great deal of attention. The progress is necessarily slow, as the conditions can only be thoroughly realized by costly experiments. The Pittsburg Steamship Company, Cleveland, Ohio, are making experiments with marine producer gas plants. The well-known American shipbuilder, Mr. Lewis Nixon, in describing the system, says that gas producers are very much alike. There is a boiler-like compartment into which the coal passes from a hopper on top; stoking is thus mechanical. This boiler is like a pot stove, and the coal burns slowly in it; the fuel really is in the state known as a "banked fire." Into this glowing mass of coal air is introduced from a pipe running into the bottom of the furnace. From a small boiler attachment steam is also let into this burning coal. The air and steam percolating through the coal give forth an unstable gas—carbon monoxide (CO)—and the steam disintegrating eventually supplies hydrogen. These gases pass out of the producer into a washer, a cylindrical tank adjoining the producer. In this washer tank jets of water clean the gas, which proceeds into a filter, where it is further relieved of tar and other elements. From the washer the gas flows into a small centrifugal pump, which takes out of the gas any liquid substance which may remain. The gas then passes into the engine, where the final combustion takes place, and the heat is converted into physical energy. The air is drawn through the coal by the suction of the engine, so that gas is made only as it is needed by the engine. Being made in this way there is no pressure; thus no gas can escape into the vessel. Gas producers can use lignites, coal, charcoal, ordinary wood, and peat. At the Standard Motor Construction Company's works, Jersey City, there is a marine engine coupled with a soft-coal gas producer, running the entire factory. With steam engines it was necessary to burn three tons of coal under the boilers; with the suction engine only 1400 pounds are now burned. In the American auxiliary schooner "Northland" and the excursion boat "Arion," gasoline engines of 500 horse-power are in operation. For battleships and merchant vessels the gas producers will come into general vogue; for torpedo boats, gasoline seems to be the ideal fuel.

ELECTRICAL NOTES.

According to L'Electricien, the special commission appointed by the federal government to deal with the electrification of Swiss railways has issued its first report, in which several waterfalls are scheduled as being necessary in the future for the electrification scheme. The second report, which has just appeared, discusses the methods by which advantage may best be taken of electric traction, notably as regards braking equipment and increasing the average speed. This report concludes in favor of electrification, which would allow more trains to be run without increasing the expenses. It also recommends that locomotives should be used on freight trains, and motor cars on passenger trains.

It is announced in Figaro that work has begun on the construction of a central station of wireless telegraphy in Paris to be used in connection with the Eiffel tower. The station itself, which will be provided with receiving and transmitting apparatus of exceptional power, is placed under ground, and is joined by wires with the extreme top of the tower. It is claimed that there are good reasons for believing that with a similar station erected in New York, direct communication between New York and Paris would be possible. Lee DeForest has announced that such a station will be established in the tower of the Metropolitan Life building and that he hopes to establish telephonic as well as telegraphic communication across the Atlantic.

A new process for incandescent lamp filaments has been lately patented by the Siemens-Halske firm of Germany, and is used in order to obtain filaments of tungsten. The process allows of using the die plate for drawing a non-ductile metal. The metal in question, tungsten for instance, is surrounded by a thin layer of a ductile metal, and the whole is drawn through the die. When the proper diameter has been obtained in this way, the filament is fixed to a conducting support in a suitable way and the whole is mounted in a glass bulb. After making a vacuum the current is put on and we raise the temperature gradually up to incandescence. Owing to the heat, the outer coating of ductile metal is driven off and the tungsten filament remains.

Mr. Richard R. Taylor maintains that if the water-power possibilities of New York State were developed as they ought to be, they would be worth more than all the coal mines of Pennsylvania, and be of continual value for centuries after those coal mines, which are unrenewable, are exhausted. We have reason to be thankful that a few of our people are awaking to the importance of this great subject, but unfortunately, too many who are waking up are waking up only on one side of the question, and they think that one course of proceeding will handle the problem. This is notably true of some of those who are getting interested in forestry. Many think that forestry alone will do the whole thing; that is a great mistake. Reforestry will greatly mitigate the floods, but is only part of the treatment necessary. The other part is the impounding of these flood waters in the up-country and where land is not so valuable.

The paper read by Mr. E. A. Watson to the Institution of Electrical Engineers recently on the "Electric Strength of Compressed Air" is of great importance. The author carried out in the laboratories of Liverpool University an extensive series of tests on the electric strength of air at pressures varying from 15 pounds to 200 pounds per square inch, and has obtained most interesting results. By the aid of formulæ obtained four years ago by Dr. A. Russell he proves first of all that the sparking distance for a given applied voltage can always be predicted with a maximum inaccuracy of less than 1 per cent, and verifies that 100,000 volts will spark over an inch when the electrodes are large. He finds that the usual assumption that the sparking distance varies inversely as the air pressure is not strictly correct; but he proves that it follows a very simple law, and so can be predicted with high accuracy at any air pressure. Under pressures easily obtainable in engineering work the electric strength of air reaches values comparable with those obtainable with the best solid and liquid dielectrics. Compressed air can therefore be utilized most usefully in connection with the apparatus required in high voltage power transmission. Its viscosity also is absolutely negligible when compared with liquid dielectrics, and there is absolutely no residual charge effect. For wireless telegraphic work air condensers have hitherto only had a limited use, as high voltages could not be used owing to the sparking between the plates. The author's results show that by using compressed air between the plates the condensers can be made more efficient than when glass is employed as the dielectric. Unlike most technical papers, it is eminently readable, and the author is to be congratulated on having brought to a successful issue experiments which must have made great demands on his patience and skill.

TRADE NOTES AND FORMULÆ.

Blotting Block.—Steep 50 parts of wool fibers in 1,000 parts of water, in which 4 parts of soda have been dissolved; in addition, mix 945 parts of calcined plaster with 1 part of tartaric acid and add the powder to the soda solution. The carbonic acid set free, aerates the plaster paste, forming a very porous mass which very readily absorbs ink and other fluids.

Artificial Lithographic Stone.—Dissolve collodion wool in a mixture of ether and alcohol, or in a solution of camphor in alcohol, or some other known solvent and by stirring finely pulverized lithographic stone into the solution a plastic mass is produced and from this the artificial stone slabs, which, after the solvent has evaporated, display all the properties of natural lithographic stone.

Fire-Extinguishing Bottle with Fragile Separating Walls.—In the central separating wall an explosive cartridge is inserted, which breaks the separating wall, thereby permitting the fluid acid and dissolved carbonate to run together, as soon as flame or electricity causes the explosion. The carbonic acid developed then throws the outer envelopes aside and enters the threatened space.

Lemonade Powder and Lemonade Candies.—As a foundation substance, prepare a mixture of ¾ ounce of powdered citric acid, ¾ ounce of sugar, and aromatize with 3 to 4 drops of oil of lemon, 10 drops of raspberry ether, 15 drops of essence of woodruff, and 3 drops oil of orange. If a lemonade powder prepared according to the foregoing recipe is mixed with bicarbonate of soda and tartaric acid, in the proportion of 19 parts each of lemonade powder and bicarbonate of soda and 9 parts of tartaric acid, a mixture is obtained that can be sold either in powder form or compressed into lemonade drops.

Linoleum Dressing.—I. 5 parts of white mofetti wax are melted, then mixed with 10 parts of oil of turpentine and set aside to solidify. If a color is desired, add annatto, curcuma, or fat-soluble aniline colors to the mixture. This dressing has a buttery consistency, is easily applied and gives a brilliant, lasting polish. As mofetti wax is cheaper than ceresine, the mixture may be profitably made up. II. 1,000 parts of yellow wax, 500 parts of potash, rubbed down in 5,000 parts by weight of boiling water, and colored dark, according to preference. To the wax, first melted, the solution is added on the fire, constantly stirring in the course of half an hour. III. 50 parts of yellow wax and 100 parts carnauba wax are melted in a steam bath. Then add, avoiding excessive heating, 450 parts oil of turpentine, and 400 parts of benzine; stir until cold and fill into tin boxes.

Copying Ink.—I. Over 250 parts of coarsely reduced Campeachy-wood extract pour about 3,000 parts of distilled water, allow it to stand until the water is thoroughly saturated with the dye stuff. After about 14 days, filter the fluid poured off the sediment, and add to it about 20 parts of acetate of manganese, shake thoroughly and add enough acetate of iron to produce an intense violet blue color. Then add a few parts of sugar or dextrine solution. II. According to Kayser, logwood is boiled out repeatedly in soft water, preferably rain water, and the decoction evaporated until, when cold, it has a specific gravity of 1.028. Then dissolve 10 parts of bichromate of potassium in 1,000 parts of water, add to the solution 100 parts of crystallized sulphate of alumina, 200 parts of glycerine and 100 parts of rock candy, and heat for half an hour to boiling. The latter solution is, when cold, added to 10,000 parts of the logwood decoction and then 100 parts of 50 per cent acetic acid added. The thoroughly shaken up mixture is then allowed to settle for a week and the clear supernatant fluid poured off. The ink flows brownish red from the pen, turns in a short time to brownish-black and possesses an excellent copying power.

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